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Statistics Education Research Journal

Statistics Education Research Journal is published by the International Association for Statistical Education to:

- encourage research activity in statistics education;
- advance knowledge about students' attitudes, conceptions, and difficulties as regards stochastic knowledge;
- improving the teaching of statistics at all educational levels.

It encourages the submission of quality papers, including research reports, theoretical or methodological analyses, literature surveys, thematic bibliographies, summaries of research papers and dissertations. Contributions in English are recommended. Contributions in French and Spanish will also be accepted. All the papers will be refereed.

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Submissions

Manuscripts should be sent to one of the editors, by e-mail, as an attached document, in rtf format. Two files are required. In one of them the author's name, affiliation and references to the author's previous work should be removed to ensure anonymity in the reviewing process. Manuscripts should conform to the style specified at the Journal web page: http://fehps.une.edu.au/serj

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EDITORIAL

For some time now IASE members have been suggesting that IASE should have its own research journal as a vehicle through which we could encourage research in statistics education, advance our knowledge about student's attitudes, conceptions and errors as regards stochastic knowledge, and improve the teaching of statistics at all educational levels. We are happy to present to you this first issue of the *Statistics Education Research Journal* (SERJ), which we hope will develop to fulfil these aims.

SERJ will continue and build on the *Newsletter of the International Study Group for Research in Learning Probability and Statistics* (ISGRN) and the *Statistics Education Research Newsletter* (SERN). The ISGRN was conceived in 1988 by Joan Garfield. It appeared initially in a printed version and, from 1996, when Carmen became editor, in an electronic version. After four years of electronic editions (now available at http://www.ugr.es/~iase/isg.html) ISGN became an IASE publication and was changed into SERN to better serve the aim of distributing information about research in statistics education (SERN is available at http://www.ugr.es/~batanero/sergroup.htm). Joan continued contributing to SERN as an associate editor until very recently, when she needed to reduce her workload. We are very indebted to Joan whose vision of a newsletter and effort over 13 years enabled researchers to get acquainted with one another and informed them about new developments and directions in statistics education research.

The impact of the newsletters was also due to the inspiration and interest of our dear friend John Truran, who was associate editor for both ISGN and SERG and was working with us to prepare this first issue of SERG until his death in December 2001. John was unfortunately unable to see the result of his work, although his ideas are still guiding us. We expect to achieve the quality he expected for SERJ in the near future. We are starting this first issue with a note about John's contributions to statistics education, the summary of his Ph.D. thesis and a selected list of references.

There are many problems regarding the provision of training for research in statistics education that must be solved if statistics education is to become a more mature discipline. At present this training is being carried out across a variety of different departments, such as statistics, mathematics education or psychology. New researchers sometimes need to start a research project in statistics education by themselves and other times they need to travel abroad to complete a thesis in a foreign language. In this issue of SERJ a thematic set of short notes serves to share some of these experiences, in the hope that this will encourage others, and cause readers to reflect on the training of researchers.

The International Research Forums on Statistical Reasoning, Thinking and Literacy (STRL) were started in 1999 at Kibbutz Be'eri, Israel, and continued in 2001 in Armidale, Australia. They gather together researchers who are interested in reflecting on the specific topics of statistical reasoning, thinking and literacy and give rise to suggestions for new research in the area. We are including a report of the first two conferences focussing on these areas, and summaries of the papers presented in STRL2.

This issue concludes with a bibliography on variation, a short paper, and sections formerly in SERN: summaries of recent dissertations and research papers, information about past and forthcoming conferences. In this sense it is not very different from recent issues of SERN, which had already begun to include contributions which would have been suitable for inclusion in a journal. Some of the material in this issue had already been prepared for the newsletter. We intend to increase the number of high quality refereed papers as SERJ develops.

We hope all IASE members will be interested in this new IASE publication, since its success can only be achieved with the help of all those who are committed to improving the quality of statistics education through research. Since the aim of the Statistics Education Research Journal is to provide a chance for all statistics education researchers to present their works and exchange their ideas, we invite you to send papers of potential interest, summaries of your theses and papers, and information about statistics education conferences to one of the editors. Details of the form in which submissions should be made are given on our web page http://fehps.une.edu.au/serj .

CARMEN BATANERO and FLAVIA JOLLIFFE

INTRODUCTION TO THE EDITORIAL BOARD

The founding members of the editorial board are Carmen Batanero and Flavia Jolliffe (editors) assisted by Annie Morin, Maria Gabriella Ottaviani, Chris Reading, and Chris Wild. Below are some details of their involvement in statistical education. They all have many other professional interests and activities in addition to those described here.

Carmen Batanero is a Senior Lecturer in the Department of Mathematics Education at the University of Granada, Spain. Before entering this Department in 1988, she worked in the Department of Statistics where she taught probability and biostatistics for 11 years. She is presently teaching statistics and statistical education, doing research and supervising doctoral dissertations on statistical education, in addition to being involved in doing consultancy and in the statistical training of researchers in education. Her publications include research papers and books directed to teachers. She helped to establish a new stochastics group at PME (Psychology of Mathematics Education), edited the *Newsletter of the International research Group for Research on Learning Probability and Statistics* from 1996 to 1999 and the *Statistics Education Research Newsletter* in the past two years. She is President of IASE for the period 2001-2003.

Flavia Jolliffe lectures in statistics at the University of Greenwich in London in the UK. She has been interested in statistics education as a discipline since the mid nineteen-seventies and has had papers published in this field regularly in either journals or as conference proceedings since 1976. She has participated in all the International Conferences on Teaching Statistics to date, and in two IASE Round Tables, and expects to be at ICOTS 6. She has written three books, including *Teaching Statistical Concepts* (with co-authors Anne Hawkins and Leslie Glickman) which was published by the Longman Group in 1992. In 1993 she started an education column in *RSS News*, the newsletter of the Royal Statistical Society (RSS) and compiled this until 1998, and she was on the board of the *Journal of Statistical Education* from 1996-99. She has served on the education committee of the RSS, has chaired the RSS education section since 1999, and has been a member of IASE since its foundation. She is also involved with activities of the RSS Centre for Statistical Education.

Annie Morin is a Lecturer in statistics in the Department of Computer Sciences at the University of Rennes 1 in France. She is presently the head of the IREM Institute of Research on the Teaching of Mathematics in Rennes. She has been interested in statistics education since 1980 especially that at the secondary school level. She edited an official report on the teaching of statistics in France in 1992 and started a small publication for secondary school teachers. She has produced distance learning material in statistics for employees and people working in industry. She is currently serving on the educational committee of the French Statistical Society. In addition she is currently working on statistical methods, mainly factorial data analysis and clustering and text mining.

Maria Gabriella Ottaviani is Professor of statistics in the University of Roma "La Sapienza". She began to be interested in statistics education in 1982 when she presented an invited paper on the teaching of statistics in the Italian universities at the meeting of the "Association des Statisticiens Universitaires" in France. Since then her interest towards the teaching of statistics has grown. She has published articles on the history of the teaching of statistics at the University level in Italy, and also in Europe and in the US. She has published papers on statistics in Italian school text books, and on the way statistics was taught in some Italian schools, with an advanced statistics curriculum. She is also interested in the teaching of statistics with multimedia and edited a volume on *"Multimedia and new educational environments".* She took part in the Italian Children's Census in 2001. She was IASE President from 1997 to 1999. She is the Chair of the International Programme Commitee of ICOTS 6. She is in charge of the Italian permanent group for teaching statistics of the Italian Statistics Society, is on the board of the Journal *Induzioni*, the Italian journal on teaching statistics, and is a member of the Council of the CIRDIS, the Italian Inter-University Center for Research on Teaching Statistics.

Chris Reading has lectured since 1997 as part of the information technology team within the School of Education at the University of New England (UNE) in Australia. Her interest in the field of statistics education began in 1976 with postgraduate research and tutoring in the School of Mathematics and Computing Science at UNE. This interest developed further with fourteen years of teaching mathematics at secondary level and completion of a PhD on *Students' Understanding of Statistics.* Chris first presented research findings in statistics education at the International Conference on Teaching Statistics (ICOTS) in 1998 but has since delivered research papers, and been involved with the statistics education discussion group, at the Psychology of Mathematics Education (PME) conferences in 1999, 2000 and 2001. She hopes to present at both ICOTS and PME in 2002 and will be a co-leader of the discussion group at PME. Chris co-chaired and was local organizer for the Second International Research Forum on Statistical Reasoning, Thinking and Literacy held at UNE in 2001. She is also a project leader for the statistics education team within the Centre for Cognition Research in Learning and Teaching (CriLT) at UNE.

Chris Wild is Professor of statistics at the University of Auckland, New Zealand, President Elect of IASE and co-author with G. A. F. Seber of *Nonlinear Regression* (pub. Wiley, 1989) and *Chance Encounters: A first course in data analysis and inference* (pub. Wiley, 2000). He has been an Associate Editor of *Biometrics*, and is currently an Associate Editor of *The International Statistical Review* and *The Australian and New Zealand Journal of Statistics*. Although his main research contributions have been in statistical methodology he also publishes in statistics education where his major interest is in the ways in which statisticians think and how these thinking patterns might be passed on to students.

JOHN M. TRURAN (IN MEMORIAM)[(1)]

We recently received the sad news about John Truran, who had a major stroke on Monday 10th December but despite outstanding medical care and support died at 9 a.m. on Sunday 16th.

In his recent thesis, John describes his personal experience as a student, a teacher and a researcher. He was born in December 10th, 1940. His primary schooling was at Westbourne Park Primary School, a government school near his home, in Adelaide, where he was advised to study mathematics. From 1959 to 1962 he studied Pure and Applied Mathematics and Education at the University of Adelaide. He graduated as a Bachelor of Arts (Pure & Applied Mathematics) and became interested in education on the influence of L. F. Neal and Z. P. Dienes. John completed at the University of Adelaide his Diploma in Education.

From 1963 to 1964 he taught junior mathematics and many other subjects at Unley High School, a prestigious school in Adelaide. In early 1965 he was appointed to teach mathematics at Edmonton County Grammar School, North London, and after two terms he taught from 1965 to 1968 at Abingdon School, Berkshier, a pilot school in the School Mathematics Projects. He was invited to become an author in the project and was involved in the writing and trailing of the books. At Abingdom he taught several courses on statistics with special emphasis on biological application, one of his fields of interest.

From 1969 to 1973 he taught senior mathematics classes at Melbourne Church of England Grammar School a school, which put great emphasis in professional development for teachers. The way in which probability was taught worried him and his revised ideas on the topic formed later the basis for his Master's dissertations. From 1974 he worked mainly in Adelaide as a freelance teacher and tutor of mathematics, in different schools and Universities, He also taught mathematics education in the Schools and Departments of three Universities. In the period 1988–2000 he was Part-time lecturer in Travel, Workers' Educational Association of South Australia.

In 1993 he received a Master's degree for his thesis *The development of children's understanding of probability*, which contained a mathematical analysis of some aspects of probability, a summary of current research and an investigation on children's understanding of probabilistic ideas. He argued that much current pedagogic practice was often not in harmony with either mathematical precision or research findings. After this he worked for about nine years to produce his Doctoral thesis, which was recently finished (we are reproducing the summary below). As John's states in the first chapter, this thesis is really the second volume of a single piece of work. This thesis was conceived with two main objectives. The first was to analyse the teaching of probability within a wide theoretical framework, within the specific context of South Australian schools. The second was to use this analysis to propose and test effective ways of improving the teaching and assessment of the topic.

Over 30 years John and his wife Kath, who became his main collaborator, have actively been engaged in mathematics and stochastic education, in particular in the teaching and understanding of probability in primary school levels. John was also interested in the inference, independence, correlation, variance, history of statistics education, mathematics, cultural factors and curricular development and in a number of topics in mathematics, science, history and other topics. He attended and presented refereed and invited papers in many statistics and mathematics education conferences, including PME (Psychology of Mathematics Education), ICME (International Congress on Mathematics Education) MERGA (Mathematics Education Research Group of Australasia), Australian Association of Mathematics Teachers, Mathematical Association of Victoria, ICOTS (International Conferences on the Teaching Statistics), and AusICOTS.

He produced a huge number of papers in stochastics, including his Master's thesis and his PhD thesis, which is an impressive and careful work, where his wide experience and culture are reflected. Another main contribution is his help in organising different events, such as several sessions at MERGA conferences, the Stochastic Working Group at PME and the Session 8.1 Cultural/Historical factors at ICOTS 5, Singapore, 1998.

John was conscious of the current limitations in our understanding of statistics education and of the need for further research. A particular problem for him was the diversity in the field, which causes that research results are widely spread in different journals and conference proceedings and many of them have not had adequate diffusion. This lead him to actively engage in the promotion and diffusion of statistics education research in different fora: In 1996 he re-started the PME Stochastic Working Group that had been created in 1994 by

(1) *Statistics Education Research Journal 1(1), 6-13, http:/fehps.une.edu.au/serj*
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Katherine Hart and had being discontinued after 1994. This group was transformed into the PME Stochastics Working Group in 1997 with the specific aim to link researchers in statistical education coming from diverse areas such as Psychology, Education and Statistics. He has continued leading this group until his death and has maintained an informal network between PME Conferences by means of an electronically distributed newsletter. A main concern of John was to bring together interested people from all language groups, as he was very sensible to linguistic difficulties. Being able to understand French, Spanish and German, he did his best to provide translation facilities at the PME stochastic working group as appropriate. A total of 28 newsletters, which also helped to diffuse IASE works and in general statistics education conferences and paper are located at the PME web server at ujaen.es/huesped/stochastics/. Last newsletter was produced in May 2001.

John became Associated Editor of the *Newsletter of the International Study Group for Research on Learning Probability and Statistics* in 1998 and continued this work until we transformed this newsletter in the *Statistics Education Research Newsletter*, where he still was Associated Editor for 2000 and 2001. In this role he helped to prepare the editorial notes, provided many reports for the two newsletters, including conference reports, notes about the work of some colleagues, and summaries of publications. A main contribution was the edition of the various specific bibliographies that were published in these newsletters, as well as translating or improving English in documents sent by non-English speakers.

Other positions of educational and community leadership included Secretary of the Environmental Studies Association of Victoria (1972-73), Member of the Committee of Adelaide Consortium for Mathematics Education and editor of its Newsletter (1990-97), Australian College of Education Treasurer (1995–1997), Member of the Editorial Panel, *Australian Mathematics Teacher (1991-97),* St Mark's College Foundation, University of Adelaide Board Member (1994–1998), Post-Graduate Students' Representative on the Board of Graduate Studies, University of Adelaide (1995-96), Representative of the South Australian Ornithological Association on the Exotic Birds Advisory Committee of the Animal and Plant Control Commission of the South Australian Government (1995-99), and co-editor, *Proceedings of Conference of Mathematics Education Research Group of Australasia, Adelaide,* July, 1999. He also acted as a referee for a number of education journals, books and conferences.

John was consultant on mathematics education issues to the Minister for Education, New South Wales in 1997, received a research grant from Faculty of Economics, University of Adelaide to examine students' understanding of statistical ideas and ways of improving the teaching of first year statistics (with Anne Arnold) in 1997-98, was research assistant to Peter Brinkworth, Flinders University of South Australia, to investigate secondary students' views of mathematics in 1997 and to Professor Kath Hart, University of Nottingham in 2001.

At the moment he died John was helping as an Associate Editor in the planning of the *Statistics Education Research Journal*, which we are now starting and this issue still includes some of his reports. The editors and the IASE Executive Committee are indebted to John for all his work and will try to continue his labour on behalf statistics education research.

It is difficult to summarise in just a few paragraphs John's contribution to statistics education. We are writing these lines as a modest homage to the colleague that, in spite of the physical distance has closely and continuously worked with us in the past years. Throughout this time we were able to perceive his passion for work, his brilliant ideas, critical attitude, vast culture and knowledge.

At a personal level, we shared scarce, but valuable moments that we will remember for life, in which we knew of his sense of humour, kindness, interest toward other people's life and work. Many IASE members sent us their words of condolence; all of us are going to miss the colleague and the friend.

THE TEACHING AND LEARNING OF PROBABILITY, WITH SPECIAL REFERENCE TO SOUTH AUSTRALIAN SCHOOLS FROM 1959-1994

JOHN M. TRURAN (2001).
PhD. Thesis: University of Adelaide, South Australia.
Supervisors: Dr Paul Scott and Miriam Brice.

The teaching of probability in schools provides a good opportunity for examining how a new topic is integrated into a school curriculum. Furthermore, because probabilistic thinking is quite different from the deterministic thinking traditionally found in mathematics classrooms, such an examination is particularly able to highlight significant forces operating within educational practice.

After six chapters which describe relevant aspects of the philosophical, cultural, and intellectual environment within which probability has been taught, a "Broad-Spectrum Ecological Model" is developed to examine the forces which operate on a school system. The Model sees school systems and their various participants as operating according to general ecological principles, and interprets actions as responses to situations in ways which minimise energy expenditure and maximise chances of survival. The Model posits three principal forces-Physical, Social and Intellectual-as providing an adequate structure.

The value of the Model as an interpretative framework is then assessed by examining three separate aspects of the teaching of probability. The first is a general survey of the history of the teaching of the topic from 1959 to 1994, paying particular attention to South Australia, but making some comparisons with other countries and other states of Australia. The second examines in detail attempts which have been made throughout the world to assess the understanding of probabilistic ideas. The third addresses the influence on classroom practice of research into the teaching and learning of probabilistic ideas.

In all three situations the Model is shown to be a helpful way of interpreting the data, but to need some refinements. This involves the uniting of the Social and Physical forces, the division of the Intellectual force into Mathematics and Mathematics Education forces, and the addition of Pedagogical and Charismatic forces. A diagrammatic form of the Model is constructed which provides a way of indicating the relative strengths of these forces.

The initial form is used throughout the thesis for interpreting the events described. The revised form is then defined and assessed, particularly against alternative explanations of the events described, and also used for drawing some comparisons with medical education. The Model appears to be effective in highlighting uneven forces and in predicting outcomes which are likely to arise from such asymmetries, and this potential predictive power is assessed for one small case study. All Models have limitations, but this one seems to explain far more than the other models used for mathematics curriculum development in Australia which have tended to see our practice as an imitation of that in other countries.

JOHN M. TRURAN. SELECTED REFERENCES

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SHARING EXPERIENCES IN THE TRAINING OF RESEARCHERS[1]

Keywords: *statistics education research; training researchers; doctoral and masters' programmes.*

1. INTRODUCTION

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This collection of short articles has been written by statistical education researchers who have agreed to share their experiences of training researchers in this area. The contributors come from several different countries and include both those who are relatively new to this field as well as those who have been working in it for several years. Some of them write about their own experience in becoming a statistical education researcher and some give information and advice about the training of other researchers.

Several contributors state that researchers in statistical education need knowledge in both statistics and education. In making comparisons it is important to realise that in some countries PhD students attend taught courses as well as writing a thesis, in others the award of a PhD is based on a thesis alone. Clearly some teachers feel the need for research results in statistical education, and it is encouraging that some are likely to make use of the results of their own research in the classroom. By providing something of a global picture of a variety of situations it is hoped that these contributions will help both to identify some of the problems in training researchers and to suggest ways of dealing with these problems, and hence will help to increase the number of statistics education researchers and the status of statistics education research in the world. In its turn this should improve the teaching and understanding of statistics at all levels.

The articles by Joan Garfield and Lionel Pereira-Mendoza are concerned mainly with PhD supervision. Joan describes the supervision experience of recent US doctoral students in statistics education. Most of them had come into statistics education because of their experience in teaching statistics, and those who had completed their research were teaching. Joan notes that it appears to be easier to do statistical education research within mathematics education, a situation which occurs in many countries, but it is encouraging that there are plans for the development of formal programs in statistics education in the US. Lionel gives his thoughts and advice as regards PhD supervision based on his own experience as a supervisor, concentrating particularly on what he feels is important in supervising someone working in the area of statistical education.

Carolina Carvalho, David Green and Chris Reading tell us about their own research. David and Chris give very honest accounts of their development as statistical education researchers. Both have been fairly isolated as researchers but stress that it is important to have contact with other researchers. David ends with some recommendations for those undertaking statistical education research. Carolina gives an account of her doctoral research in which she looked at the role of peer interaction in the study of statistics in the 7th grade in schools in Portugal. Her results suggest that working together is beneficial to pupils. She points out that teacher training is important as it is not always easy for teachers to introduce new methods.

Ernesto Sánchez, and Michel Henry and Bernard Parzysz tell us about statistics education research training in their countries. Michel and Bernard discuss the situation in France and how changes in the teaching of probability and statistics at school level drive research. They think that those doing research concerned with teaching these subjects should have an academic background in them, but should also have some training in didactics. They describe the IREM network in France which links research on the teaching and learning of mathematics and teacher training and has within it a working group on statistics and probability. Ernesto writes about the position in Mexico. As yet there is little activity as regards research in statistical education, and what there is tends to come via mathematical education and teaching experience. He comments that the students under his supervision perceive statistics to be "hard".

Carmen Batanero writes about the difficulties of setting up what has become a very successful and renowned research group with an associated training program. She gives details of the program in which educational theory and research methods are important components. Carmen hopes that their experience in

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International Association for Statistical Education

Spain will encourage others to set up doctoral programs.

Susan Starkings describes how the statistical support service at her university in London can help statistical education researchers who are not statistical experts. This service is given within a mathematics support section. She remarks that research supervisors do not always have relevant statistical knowledge and that those new to research do not always think through their investigations in full before they start. She too, like several other contributors, makes the point that researchers in statistical education need knowledge of pedagogical issues.

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2. RECENT PHD'S IN STATISTICS EDUCATION

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Statistics Education is a relatively new discipline that is growing in interest and activity. People conducting research in statistics education come from a variety of different areas and often have very different backgrounds, coursework, and training. Over the past year I became interested in learning more about graduate students in the USA who have decided to pursue degrees in statistics education. I conducted e-mail interviews, using a short questionnaire containing open-ended questions, with eight current doctoral students and recent PhD's whose dissertation research focused on statistics education. I wanted to learn about their coursework, their training in research methods, and the topic of their dissertation study. I was also interested in finding out the nature of their experience designing and completing a degree that focused on statistics education. These eight individuals shared with me their reflections on the process of earning a doctoral degree in statistics education and offered advice to future graduate students interested in pursuing this path.

Through word of mouth and personal contact, I obtained the names of these eight individuals who had recently graduated or were in the dissertation process, and all agreed to be interviewed. They were the only ones in this position whom I was able to identify at that time. Each individual has a different story about how they came to be interested in statistics education, how they designed a program that would allow them to develop the expertise needed to do a dissertation in this area, and how they were able to complete the requirements and overcome obstacles along the way.

Most of the people interviewed came to statistics education because of their experience teaching statistics. Many expressed their enjoyment teaching statistics, but also expressed a concern over difficulties students have learning statistics, solving statistical problems, and using statistical thinking, which led them to study and pursue research in this area. Only one person chose this area because of her advisor's research interests. Two people indicated that they specifically planned to teach statistics at the college level and thought that this degree would best prepare them. These eight individuals entered graduate programs in statistics, mathematics education, or educational psychology programs. Based on their experiences, it appears to be somewhat easier to design a statistics education focus within a mathematics education department than in other departments. Many students outside of mathematics education either had to combine programs (e.g., statistics and education) and have co-advisors, or switch advisors to find one that approved of a dissertation in statistics education.

One interesting distinction between students in the three different areas has to do with the type of job preparation they receive. Most mathematics education programs are focused on teacher education (i.e., teaching those who will prepare math teachers) while the combined programs of statistics and education are focused on training individuals to be teachers of statistics themselves, typically at the college level. Students in Educational Psychology are prepared to teach quantitative methods (to graduate students in Education) and to conduct research in the area of educational statistics.

The coursework taken by these people varied according to the type of department they were in. For example, students in Educational Psychology programs took mostly courses in that department (e.g., statistics, measurement, and learning) and were less likely to take courses in mathematics education. Students in mathematics education programs appeared to have more varied programs with courses in educational psychology and statistics in addition to mathematics education. Several people found their coursework in psychology or learning and cognition to be the most helpful in preparing them to do research in statistics education, while others noted their coursework in statistical methods was particularly valuable. Most of the students across programs valued preparation in both quantitative and qualitative research methods.

Getting a dissertation topic approved was often a hurdle, and a few students experienced reluctance from their advisor to agree to a focus on a statistics education topic, feeling that this would limit their job possibilities. In the cases where students had co-advisors, getting approvals from two advisors and two departments was often challenging and took extra time. Most of the people interviewed were the first person to design a statistics education program and dissertation either at the institution or with their advisor. One person commented: "My biggest obstacle was that since no one had done this before I was on my own for a lot of it in deciding what courses I should take and what an appropriate dissertation looked like."

Being connected to the wider statistics education community via meetings and newsgroups has been very helpful to many of the people interviewed. One person commented "I would especially like to acknowledge how wonderful the statistics education community has been about welcoming me into the fold. I have met some terrific people and made some great connections and look forward to continued work with these people."

Others wish there could be more recognition of and validation for statistics education as a legitimate area for study and research. "As more students pursue degrees in statistics education it is important to identify faculty members as advisors who have comfort and expertise in both fields, education and statistics." "While looking for a job, I was asked a few times what exactly a statistics education degree was. I had the most success in answering this question by saying that it was like a mathematics education degree."

Those who have finished degrees are teaching in a variety of settings, and appear quite satisfied with their decision to focus on statistics education. One person remarked, "I am very happy I chose the field I did. My teaching and my research feed off each other, which is very meaningful to me… I'm excited by the 'newness' of the field. There are so many directions in which we can go and I am happy to be near the beginning of that exploration."

Since conducting these interviews I have learned of at least two other USA graduate students, both in departments of mathematics education, who are working on dissertations focused on statistics education. These studies examine middle school or high school teachers' knowledge and understanding of statistics, an emerging area of interest to statistics education researchers. With more formal programs in statistics education beginning to be developed (e.g., at the University of Minnesota beginning in Fall 2002), the statistics education community should begin to provide a more consistent and complete training to prepare and support future teachers and researchers in this emerging discipline.

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3. TRAINING FUTURE RESEARCHERS IN STATISTICS EDUCATION: REFLECTIONS FROM THE SPANISH EXPERIENCE

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The Doctoral Programme in Mathematics Education at the University of Granada was started in 1988, with only three lecturers in charge of teaching the courses and supervising research, one of them coming from the Department of Statistics and with no experience in educational research. Fortunately we counted on the help of a very experienced French research team in mathematics education: professors, Michéle Artigue, Ives Chevallard, Regine Douady, André Rouchier, coordinated by Guy Brousseau, who travelled to Granada to teach some of the courses and helped in the orientation of the theses during the first four years of the programme. Starting the doctoral programme would have been quite impossible without their help and no doubt the influence of the French school in our research work is still visible.

There have been different regulations for doctoral programmes in Spain throughout this period. From 1988 to 2000, students were asked to complete 320 hours of regular course work and seminars, over two years part-time, with the possibility of spending up to 90 hours in the second year producing a preliminary written research monograph (similar to a Master's thesis). In the new regulations, the amount of course work is reduced to 200 hours in the first year and the second year is dedicated to producing a compulsory research monograph weighted as equivalent to 120 hours of taught material.

When the student has finished these two years and his/her research work is approved, he must work on a PhD. D. dissertation (original research, supervised by an expert in Mathematics Education or a related field), which usually takes 2-4 more years to complete. This Programme is offered within a Mathematics Education Department and most of the students who throughout these years have presented a thesis (24 at the moment) as well as other students who are currently at different stages in their research, are mathematicians. A few students have come from Education or Physics. In the last few years we have received South American students with other backgrounds, although the majority of them still have backgrounds related to mathematics. Nine students have finished their doctoral thesis in statistics education, and all of these specialised in statistics during their University studies or had been teaching statistics for a number of years before entering the programme.

3.1 CONTENTS OF THE PROGRAMME

Although some students have had experience in educational research and in teaching mathematics or statistics, the majority of them have needed to complement their theoretical knowledge about education and mathematics education. Two courses (together lasting 60 hours) on the Theory of Mathematics Education include four main components: Mathematics (Statistics) Education as a Scientific Discipline, Epistemological Foundations, Teaching and Learning Theories and Curricular Theories

The number of specific courses in statistics education has increased from only a 30 hours course in statistics education in the period 1988-1994 to 3 different courses (didactics of probability; didactics of data analysis; didactics of inference) with a total of 100 hours in the period 2000-2002. The basic content of these courses is: Current situation of Statistics Education: Epistemology of Stochastics: Cognitive development: The stochastic curriculum: Research into students' understanding and learning: Other research: attitudes, social factors, comparative studies, case studies, textbooks.

The main methodological content of the courses, which have ranged between 120 hours (in the 1988-1990 programme) to 60 hours in the 2000-2002 programme are: Research paradigms: The Research Process: Data Collection: and Data Analysis.

3.2 STARTING A RESEARCH GROUP IN STATISTICS EDUCATION

Starting in 1988 a doctoral programme with only three possible supervisors forced us to concentrate the research topics on three basic research lines: Numerical Thinking, Theory of Mathematics Education, and Statistics Education. Two of the lecturers in charge of the programme had carried out their dissertations in pure statistics and had extensive experience of statistics consultancy work in different experimental research areas, the field of statistics was familiar to them in its different facets: teaching, applied and theoretical research. That experience has also made them conscious of the problems in understanding and applying statistics and of the interest in carrying out didactical research in this area.

The fact that, after finishing their dissertations, our colleagues stayed in our department or other cities close to Granada (Jaén, Melilla) served to increase the "critical mass" of lecturers who had specialised in statistics education and who could collaborate in supervising new students. From a few initial problems: association, combinatorics, the test of hypotheses, we gradually moved to other areas, such as probability or the normal distribution. Nine doctoral dissertations have been finished in statistics education in this period and three more are currently in progress.

The doctoral programme at the University of Granada has received a great deal of support from Spanish and other European academic authorities and this has served to fund visits from the principal mathematics and statistics educators who have given us courses and discussed with us our research in progress. Statistics education research received particular support through different funded projects from the Spanish Ministry of Education. The IASE decisions to hold the ICOTS-4 conference in Marrakech and the 1996 IASE Round Table Conference in Granada served to consolidate and give impetus to our work. These meetings helped us to establish new valuable contacts and collaborations that still continue.

The list of theses, projects and publications carried out in the group is available from our web page http://www.ugr.es/local/batanero, which is also linked to the IASE and other statistics education web servers.

3.3 FINAL REFLECTIONS

Having finished the training of all the members in our own department (where there are now 18 lecturers with a PhD in mathematics or mathematics education), and also the training of other colleagues in Andalusian universities (3 in Jaén, 2 in Cordoba, 2 in Malaga) we focus now on the education of young students and South American colleagues, who in the last years were increasingly successful in getting a grant either from their own countries or from the AECI (Spanish Agency for International Co-operation), or OEI (Organisation of Ibero-american States) or other institutions. A number of doctoral dissertations by colleagues from Argentina, Colombia, Chile, Mexico and Venezuela are being prepared in Granada. When returning to their countries these colleagues usually take over responsibility for Master's or doctoral programmes in education or in mathematics education. It is, then, very likely that this collaboration can serve to spread mathematics and statistics education research in South and Central America.

In this brief report we have reflected on our particular experience in the training of researchers in statistics education from a mathematics education doctoral programme, which was started with a lot of effort, but has gradually been developed to be the main research programme in mathematics education in Spain and includes the largest statistics education research group in Spain. International collaboration was very important at different stages to start up the doctoral programme, and orientate the first theses. We hope this experience can encourage other researchers to start new programmes even with modest initial resources and in this way can serve to extend the interest towards statistics education research.

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4. ACCEPTING A CHALLENGE

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4.1. FINDING A FIELD OF KNOWLEDGE THAT WOULD ALLOW A PSYCHOLOGICAL PERSPECTIVE: THE CASE OF STATISTICS

Working in a Department of Education, in charge of Science and Mathematics teachers' pre-service and in-service training in Portugal, awoke in me the need to undertake an investigation that could be used again later by teachers in the classroom and at the same time go beyond the realisation of an academic study – a doctoral thesis.

In 1994/1995, I was confronted with César's (1994) studies, namely the results of her doctoral thesis about the advantages of peer work and the many questions which remained unanswered regarding this way of conceiving the appropriation of knowledge and the mobilisation of competencies. In an attempt to answer some of these questions I carried out research for a doctoral thesis (Carvalho 2001).

When I decided to study pupils from the 7th grade, as this was the first of three years that form the last cycle of compulsory education in Portugal during which instances of disinterest, retention and dropping out frequently happen, it seemed fit to choose a curricular unit of the Mathematics subject that had been introduced with the Reform of the Educational System undertaken in Portugal during the '80s.

Choosing the Statistics curricular unit, which in Portugal is always part of the Mathematics curriculum, both in basic and compulsory levels – nine years – and in the secondary level – three years – seemed interesting because: (a) it is a topic of the Mathematics program that has hardly been studied by Portuguese researchers; (b) it allows the creation of tasks that help in understanding the dynamics of interactions produced by the pupils when working collaboratively; (c) it explores didactic contents with situations that are close to pupils' real-life situations, thus encouraging greater motivation and adherence to the proposed tasks; (d) it holds an increasingly important position in present society, which will eventually be reflected in school programs, (e) it contributes to the development of more critical, reflective and participating citizens.

4.2. THE INVESTIGATION: A CONTRIBUTION TO STATISTICS EDUCATION.

The investigation "Peer interaction: Contributions towards the promotion of logic development and statistical performance in the 7th grade" focuses on the study of peer interactions in the Mathematics classroom, namely after the 7th grade curricular unit of Statistics has been taught. The problem under study is the understanding of the progress that occurs when pupils work in dyads on various tasks, both in terms of logic development and in terms of statistical performance. Tasks such as using a formula to calculate a quantity are said to be "usual" tasks, whereas solving problems are "unusual" tasks.

From this problem, the following main objectives were defined: (a) to verify whether pupils, when working in dyads and solving unusual Statistics tasks (Experimental Group), show more progress in their logic development in comparison to pupils who do not try this form of work or tasks (Control Group); (b) to verify whether pupils, when undertaking unusual Statistics tasks (Experimental group), show more progress between the pre-test and the post-test in comparison to pupils who do not try this form of work (Control Group); (c) to analyse certain frequent mistakes and difficulties in usual and unusual Statistics task-solving; (d) to investigate which are the most frequent solving strategies that are used by pupils when carrying out unusual Statistics tasks; (e) to identify the type of dyad that accounts for a clearer evolution of pupils in relation to their logic development, that is, between the first and second application of the Collective Scale of Logic Development, l'ECDL (Lautry 1979, Londeix 1985), and in relation to their statistical performances (between the pre-test and the post-test); (f) to state the forms of interaction dynamics used by the dyads that facilitate solutions, whether successful or not.

The chosen methodology was based on an empirical plan of a *quasi-experimental* nature, with a control group and an experimental group. The empirical work was carried out during two consecutive school years, the second year being to replicate the study on a different group of pupils. At the start of the school year, the pupils of the two schools where the investigation was undertaken solved a Collective Scale of Logic Development (E.C.D.L.) and two usual Statistics tasks that served as pre-test. Pupils' performances were the criterion for the creation of the control group and the experimental group, keeping in mind that the unit for the group creation was the class unit. At different moments and for each one of the classes belonging to the experimental group, the pupils worked in dyads to solve three unusual Statistics tasks and participated in a general debate with the researcher. One week after the dyad work had finished, the pupils belonging to both groups undertook the usual Statistics task, corresponding to the post-test. At the end of the school year, they solved the Collective Scale of Logic Development again.

The main results of this study show that, if we compare their pre-test and post-test performances, the pupils belonging to the experimental group, who worked in dyads with unusual tasks during three sessions, show clearer progress regarding logic development as evaluated by the Collective Scale of Logic Development, as well as a more pronounced evolution in their performance concerning usual tasks. We also find that in the year of the study replication, these results are more pronounced. Another finding shows that the type of dyad we create tends to account for a pattern of subject performance. The dyads we considered as being of Type IV, which are heterogeneous regarding logic development and the pre-test task performance, are those that seem to produce more progress in subjects' statistical performances. However, the data obtained are not so clear as far as logic development is concerned. This investigation also produced another result: Statistics content presents difficulties to pupils and even those working in a different manner, like the experimental group pupils, still face hindrances when solving certain post-test items. Similarly, when pupils' performances are analysed differently, namely through interaction analysis, we find that the way many pupils master statistical knowledge is confined to an instrumental knowledge, that is limited to using a procedure or resorting to an algorithm. Finally, we were also able to identify the different solving strategies used by pupils in unusual tasks, such as the trial and error solving strategy, the strategy of graphical representation with and without statistical support, the arithmetic solving strategy and the algebraic solving strategy.

The recommendations that arise from this study point towards a revision of the way pupils have been working on Statistics in the Mathematics class. Dyad work is one of the possible ways of changing these practices but, in order to do so, so that we enhance all the potential of pupils and thus facilitate the process of knowledge appropriation and the mobilisation of competencies, we should not team up pupils in dyads at random.

4.3. CONTINUING A TRAJECTORY: OUTLOOK FOR THE FUTURE

For a long time the literature has defended how important and necessary it is that Statistics teaching stops emphasising calculations and techniques, but we often find a different reality in the classrooms. In my opinion changing this reality is one of the great challenges of the future.

However, this is not an easy task when we are Mathematics teachers and are teaching Statistics and when we have never tried another method, or had pre-service or in-service training that makes us feel less uncomfortable with new working methods or contents which sometimes we do not know how to manage, such as group work or resorting to new technologies. Therefore, pre-service and in-service teacher training is a priority.

Collaborative work was shown to be a working method that allowed pupils to enrich their repertoire of statistical competencies, but there is still much to learn about how the nature of the tasks and the instructions that are associated with these affect pupils' performances.

The fact that similar difficulties to those detected by researchers from other countries were found in Portuguese students suggests that we must strive in order to understand better how statistical knowledge is appropriated by students. We must meet the need to create multidisciplinary teams with researchers from different fields as well as teachers (that is teams whose members have various perspectives) to look into these problems and enrich the analyses and understanding we have of them.

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5. LESSONS FROM THE PAST

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5.1. GETTING STARTED

From my teenage years I had wanted to be a mathematics teacher, and when I graduated I was very fortunate to obtain a 3-year Assistant Lecturer post in a College of Education. I had previously only studied a small amount of probability and statistics and was now faced with teaching these subjects to future primary school teachers whose own mathematical backgrounds were often quite limited. The probability which I had studied was very formal and mainly combinatorics, and statistics had hardly featured at all. In preparing my lectures I came across the 'Birthday Problem' which intrigued me and I introduced it to the class, but the mathematics was unconvincing, being too much of a challenge for most. That was a first valuable lesson – mere proof won't convince people! It was during this course that an even more revealing experience occurred. A mature student drove in daily on a busy road on which accidents frequently occurred. In his view every time he successfully arrived at college the chance of his having an accident *next* time was increased. This provoked a lively discussion! Was it logical? Ignoring a variety of real-world factors it would be concluded that the student was wrong – an example of the 'Gambler's Fallacy'. This was the first time I had consciously come across a probabilistic misconception. I had always thought that faulty calculation was the basis of erroneous results. A second valuable lesson! A third lesson was the realisation that mathematics – and probability in particular – provided a *model* of reality and was necessarily limited in its applicability. This was something my traditional university mathematics training had completely failed to reveal.

So much for my early experiences, which came to an end with the completion of my three-year post. Following a short period working in industry I took up school teaching, where the probability was minimal and formal. In 1972 I embarked on a part-time MEd at London University (Chelsea College). There was a course on Piagetian psychology given by Joan Bliss, who had worked with the great man – although she did not mention 'La genèse de l'idée de hasard chez l'enfant' (Piaget and Inhelder, 1951). At Chelsea College Geoffrey Matthews, Professor of Mathematics Education (the UK's first such appointment), was directing the CSMS project (Concepts in Secondary Mathematics and Science, 1974-79) the first major research project in the UK of its kind. Despite all this, probability (and statistics) education did not feature in the MEd course, reflecting the nature of the school curriculum at that time, so I gained my MEd in 1974 with little thought of probability.

When I took up a lecturing post at Loughborough University I determined to embark upon research and naturally consulted researchers at Chelsea College who encouraged me to investigate probability concepts in UK 11-16 year olds, which the CSMS project had not done. Armed with one paper which contained just one relevant reference, in 1976 I set out on a long path of discovery …

In 1975 an English translation of Piaget and Inhelder's pioneering book appeared. Although relatively clear – by Piagetian standards at least – the book was for me disappointing, having little that I could see related to mathematical concepts in the UK 11-16 education. However, in the same year (1975) a much more exciting and relevant publication appeared 'The Intuitive Sources of Probabilistic Thinking in Children' – by Ephraim Fischbein – a remarkably talented researcher.

5.2. THE CHANCE AND PROBABILITY CONCEPTS PROJECT

The late 1970s were a good time for educational research in the UK and I successfully applied for a substantial grant from the Social Science Research Council, for a three-year project (1978-81) entitled 'Chance and Probability Concepts Project' to investigate concepts in 11-16 year-olds. This was extended with a further grant and the final report was submitted in 1982 and acknowledged as "a most competent and carefully worked study" which was encouraging. It was only at the first ICOTS conference (in 1982) that I realised that the large scale testing which I had undertaken was unique in the field.

What were the problems encountered? This project involved giving two approximately 50 minute tests to about 4000 school pupils, in classes of about 25, over a one-year period, in a radius of about 50 km of Loughborough (a town 25 km south of Nottingham). This required a team of five trained interviewers and entailed considerable organisation. However, it was easy to recruit very capable people with previous school teaching experience. The real problem – only recognised as such with hindsight – was not having any academic partners. There was no lecturer colleague interested in the work, and my very able research assistant was essentially an administrator and I had no research students (this had not been considered). At the time I did not know of anyone in the world who was working in this field. This isolation was not seen as a problem at the time but has undoubtedly reduced the potential impact and extension of the basic research.

5.3. SUBSEQUENT WORK

The success of the original project encouraged me to widen the work, so as the project neared its conclusion I prepared a submission for a similar investigation into statistical concepts – arguably more relevant and important for the average citizen than the more specialised probability concepts. The bid failed. I have never fully understood this – one factor was it had become more difficult to get grant money, and another factor was that statistics – data handling – had next to no place in the secondary school curriculum. The bid was perhaps ahead of its time (or maybe flawed!).

As a consequence of this I turned my attention to probability concepts in 7-11 year olds, and following up the various ideas which emerged from this and the 11-16 year old work, reported at subsequent ICOTS and elsewhere (Green 1983, 1988, 1991), but not as fully as it should have been. This was in part because I had diversified into other aspects of mathematical education involving IT (for example, consultancy work for the Department of Education and Employment, and a fruitful and rewarding collaboration concerning dynamic geometry). In retrospect, what I should have done early on was make a concerted effort to work at length with the then current researchers (such as Fischbein, Falk and Konold). Only much later did I begin to do this – for example with a rewarding collaboration with Godino & Batanero – by which time my many other commitments (to administration, committees, national bodies) limited the time which could be devoted to this. I wonder what might have happened had I made some different decisions early on!

5.4. LESSONS LEARNED

Reviewing my own experiences and mistakes, I present below a list of the lessons and warnings for others to note. I hope at least some of them will prove relevant and helpful – I even hope to learn from them myself!

1. Initially work with the guidance of other experienced researchers.
2. Get to conferences – not just to find out what is going on around the world but, most importantly, to make personal contacts.
3. Read the literature widely - realise that there will be workers in other fields with overlapping interests so a wide range of journals will be worth perusing.
4. Seek funding to allow travel to visit other workers in the broad area, and try to develop joint projects, for prolonged collaboration.
5. Don't try to broaden your own research too soon – specialise.
6. Get a sabbatical to give yourself adequate time to develop your research ideas.
7. Make an effort to attract PhD students – perhaps through contacts with other workers in the field. Aim to build a team.
8. Don't be too influenced by early failure – try to find out why a research bid fails.
9. Make sure that research is properly written up and published in good time.
10. Avoid too much extraneous work: administration, committees, national bodies, etc.

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6. YOUNG RESEARCHERS' TRAINING ON TEACHING STATISTICS AND PROBABILITY IN FRANCE

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The teaching of probability and descriptive statistics at secondary level goes back to the 1960's. After a very abstract period during the 1970's, linked to the so-called "modern math" period, the teaching of probability progressively evolved during the 1980's. The combinatorial approach to probability, fitting in with situations of equiprobability, was replaced in 1991 by an introduction linked with the stabilisation of frequencies. The statistical tools for describing populations were introduced in 1986, as early as the beginning of junior high school (12 year-old pupils).

Recently, in the new curriculum which was set up in 2000 at senior high school level (15 to 18 year-olds), the statistical approach to the understanding of random processes has been reinforced and numerical experiments are proposed as the main access to probabilistic and statistical knowledge, by means of simulations in a computer environment. Probabilistic laws are then understood as mathematical models for concrete situations involving chance, models whose properties mirror those of distributions of frequencies of studied events, when the experiment is repeated a large number of times.

This evolution in the aims of teaching which takes into account the link between statistical processes and the theory of probability, requires a quick adaptation of mathematics teachers and implies coping with a high demand for training. This training must be based on thorough research work on the teaching of these areas of knowledge and abilities. It must also be based on experimentation in class situations, in particular with problem solving and on a didactical analysis of the learning conditions.

Until today such works are badly needed. Thus a training program for researchers on the teaching of statistics and on the planning of research should be part of the main aims of the community of researchers in mathematical didactics.

But in France, this question does not fit in with the structures of scientific research. PhDs centred on the teaching of a given subject do not enable young researchers to follow a normal academic career within this area. They are often compelled to join an educational science research team, the aims of which are quite different, since they are interested in general pedagogical questions, or in educational psychology, or sociology, or philosophy and history of education, rather than in questions of didactics.

It seems obvious, as is proved by many training actions, that in order to develop research centred on the teaching of a given subject, it is necessary for the researcher to be a "specialist" of this subject up to a level including a master's degree. This of course is also true for the teaching of statistics and probability. Most of the researchers should come from an academic background training in mathematics including statistics and probability, or from some specialised colleges such as ENSAE (École Nationale de Statistique Appliquée à l'Économie) or INSEE (Institut National de la Statistique et des Études Économiques).

The curricula in educational science include some elements of descriptive statistics, together with bases for the use of estimation and hypothesis tests, but this level of probability is not conceptually sufficient. Complementary training should be given to enable these young researchers to focus on the teaching of statistics. It is necessary that every researcher should receive a basic training in the didactics of sciences up to the postgraduate level, which is when young researchers are initiated to practising research. This is an ambitious and open perspective.

But the aim of developing research programs on the teaching of statistics faces another major difficulty, which is the almost total lack of research directors in this domain in France, since there are fewer than five specialists altogether.

There is, however, a structure which works on the link between research on the teaching and learning of mathematics and teacher training : the IREM network (Instituts de Recherche sur l'Enseignement des Mathématiques), which exists in every one of the 25 French academic centres. This network created a national working group in 1991, the "Statistics and Probability" commission. This group is composed of about 15 members. It works on the implementation of the new curricula in statistics and probability at senior high school level (15 - 18 year-old students). The commission has produced documents and books for teachers based on classroom experiments, which are analysed and discussed from a didactical point of view. The commission is also a place where secondary school and university teachers, interested in the development of research on the teaching of statistics, can get training through research.

New questions are now appearing. For instance the question of teaching randomness as early as junior high school (12 year-olds), or even at primary school. Today, the relations between statistical reality and random situations, simulations with computers and probabilistic models, are the centre of the commission's work.

A first PhD thesis (presented in June 2001 at the University of Grénoble) was a result of this research work. It focuses on the introduction of random situations in general school through various activities in a computer environment (more precisely a dynamic geometry software : cabri-géomètre II). Random situations of "repeated Bernoulli trials" have been given to the students of the experimental classes, and simulations on computers have been used. The students' behaviour has been subjected to didactical analysis, centred on the relation between the experimental situation and the theoretical model of the Bernoulli urn.

This thesis should be the first of a series, prepared by young researchers or by in-service teachers, provided that the didactical community decide to promote such research. The help of IASE will be invaluable (meetings, conferences, exchanges of information and documents, assessments of research programs ...). In particular the IASE Newsletters are of the utmost importance.

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7. EDUCATING A RESEARCHER IN STATISTICS EDUCATION: A PERSONAL REFLECTION

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As Garfield has noted in her contribution above, Statistics Education is a relatively new discipline. Also, since statistics is truly interdisciplinary some of the issues associated with the education of researchers in statistical education are different from the education for researchers in other disciplines. One of the key differences is the background of doctoral candidates. They may not come to a programme with a statistics background. This presents a different challenge from the education of a researcher in mathematics education, say, where the student would usually have a mathematics background as well as experience as a mathematics teacher.

The following is based on my experience with a recent student who graduated with a PhD in statistics education. However, it is clearly informed by previous supervisory experiences; nothing develops in a vacuum. Generalising from one subject is not a good research technique. However, I am sharing this so it may be useful to you if you are about to embark on supervising a student in this area.

Before proceeding further I need to describe the PhD process locally in Singapore, since it is different from that in the USA and Canada. In those countries a PhD has a "large" coursework component and a dissertation. The students gain their education both through the formal courses they take as well as the dissertation experience. Locally, the main focus is on the thesis. In fact, until very recently there were no required courses as part of the programme, although more recently a "small" coursework component has been included. However, the primary focus is on the research undertaken for the thesis - basically a British model. In addition, many students are here for 3 years on scholarship (this has been recently extended to 3.5 years to accommodate the fact that they will be taking some coursework). After this, while they can extend their period of study, the scholarship finishes and they are often not in a financial situation to continue at their own expense.

Given this background, what personal reflections can I include that might help a supervisor? I have focused on two that seem to be fundamental when training a statistics educator.

The first, and maybe most important, concerns the background of the student. If students pursue a programme in statistical education, often their background can inhibit their perceptions of statistical education, particularly if they have studied mathematics. With a mathematics background a view has been developed where logical reasoning, based on axioms, can be used as the basis from which valid conclusions can be drawn. Even if they have a science background, one of the key tenants of their experience is the reproducibility of experimental results. If an experiment is replicated under identical conditions then one will get the same results. When students are faced with statistical education, particularly in the area of probability, they are reasoning under uncertainty. The scientific education students have received previously can inhibit their ability to accept this "alternative" reality.

Consequently, the initial experiences given to students needs to be different. Their initial reading and reflection needs to fundamentally re-orientate their thinking. Any graduate student starts their programme by examining the literature. *It is particularly important for a supervisor to focus the student on the issue of uncertainty and how reasoning in a framework of uncertainly is fundamentally different from other forms of reasoning.* Also, some results in probabilistic situations are counter-intuitive. If a student is to pursue a career in this area it is essential that the nature of this understanding be inculcated into a schema of statistical education.

The second point deals with independent thought. A major focus of the supervision must be to develop the ability to generate and solve problems independently of the supervisor. Many of us have backgrounds as teachers. We also have particular preferences in terms of potential research topics. When students consider selecting supervisors they often seek guidance regarding potential topics. While students have various experiences in independent decision-making rarely have they had any deep experience in deciding on a research topic that they will pursue for a few years. The level of explicit direction requested will vary from student to student and culture to culture. It is particularly important to "pull back" with a view to allowing as much freedom of choice as possible. In fact, my own personal bias is to actively discourage myself from giving direction early in a programme. We all tend to believe we do this but it is particularly difficult not to give direction. Such an approach can be uncomfortable for a student since they may feel they are not getting as much direction as they expect. However, particularly *if when they graduate they are going to pursue academic careers the ability to set their own direction is an important facet of being a successful researcher.*

Clearly, there are other aspects of supervision, but on reflection these seem to me to be the key points, with the first being particularly relevant to the education of researchers in statistical education. I hope they prove useful to you in reflecting on your supervisory practice.

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8. VOCATIONAL TRAINING OF RESEARCHERS IN STATISTICAL TOPICS OF MATHEMATICS EDUCATION. AN EXPERIENCE IN MEXICO

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Even though the activity that we develop in our Department of Mathematics Education is not directly linked to Statistics departments of Mexican educational institutions, in our doctorate program there are some students whose interest is aimed towards research of topics in Statistics Education. On the other hand, as far as we know, our Department is the only one in Mexico that offers doctorate studies and research in this field.

In my particular case, my vocational training is that of a mathematician whose personal interests took him to study Probability and Statistics among the optional courses of the Mathematics degree. My Master's thesis in Mathematics Education is related to teaching models for the learning of probability. My doctoral dissertation (done like the Master's at the Centre for Research and Advanced Studies of the National Polytechnic Institute in Mexico) is about probability too; specifically it is related to concepts of Stochastic Independence. I have also taught Probability and Statistics courses at both high school and university levels. Through these experiences I had the opportunity to familiarize myself with the literature available in the area of Statistics Education, particularly in relation to students' difficulties with and beliefs concerning probability concepts.

As in my case, the three doctorate students under my supervision are not professional statisticians. One of them is a mathematician and the other two are engineers, but they have all specialized in the teaching of Probability and Statistics. They are currently working in topics of Statistics related to Mathematics Education. Their interest comes from their teaching experience and their conviction that statistics is a hard-to-teach and hard-to-learn subject matter.

It may be worth noting that in the courses that these post-graduate students can take as part of their doctoral studies, they may become familiar with other research topics such as those related to the teaching/learning of Algebra, or of Geometry, or topics as diverse as Problem Solving.

I think my experience is representative of what happens in Mexico in relation to the links between the institutions in which Statistics is taught, and those focused towards training researchers in Mathematics Education. It is clear that there is a need for greater collaboration between the research institutions in Mathematics Education and those specialized in training statisticians, in spite of the fact that it is my belief that the latter do not see the problems of Statistics education as a field of research.

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9. REFLECTIONS FROM MY EXPERIENCE

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Given that my PhD, upon submission, had ruled my life totally for one fifth of my existence and seen my supervisor through two restructures, which had him working first at a teachers' college and later at a university, one might wonder what would lead someone to embark on such an adventure.

Following my undergraduate studies in Mathematics and Statistics at the University of New England (UNE) in Australia, I undertook an Honours and Masters of Science program in statistics with a Diploma in Computer Science, on the side, as I needed to estimate some, as yet, untabulated integrals. At this stage, mathematics education operated from within the Mathematics and Computer Science Department at UNE. Although I completed a Diploma in Education, attending some classes at the local teachers' college, in preparation for teaching Mathematics, my first seven years of work involved tutoring in a variety of undergraduate statistics courses, both theoretical and practical, at UNE.

When university funding was reduced I moved on to teaching mathematics, and subsequently computer science, at a local high school. I always maintained my ties with the university by studying some Australian History, before embarking on a Masters of Education. A requirement of my first unit of study, research methods, was to produce a research proposal and although my initial interest had been to research the use of computers in education, still in its infancy in the mid 80s, a lecturer in Mathematics Education convinced me to change direction and investigate levels of students' statistical understanding. His main interest was in Structured Observed Learning Outcome (SOLO) levels and he was recruiting a number of PhD students to investigate the use of the SOLO Taxonomy in a variety of fields. Recently rereading my research proposal prepared as part of the assessment in research methods, I was amazed at how closely it resembled the finished product, my thesis, so many years later. After one semester of study towards my Masters of Education my future supervisor, a SOLO expert, convinced me to alter my enrolment to a PhD and, as he was a member of the Faculty of Science, that was where my enrolment was initiated. Although, this constituted a relatively painless conception, the gestation and final birth of my PhD was a long slow process.

Early on I was encouraged to read widely and to produce my first two literature review chapters while I was piloting some open-ended questions to use with students in the main study. Although the reading and writing did not seem as interesting as collecting data, at the time, in my later write-up stage I appreciated that these early chapters had already been produced, even though they had to be brought up to date. However, in my next step of collecting data and analysing the responses I was really a little out of my depth. The only contact I had was with my supervisor who, although well versed in the SOLO Taxonomy which I was ultimately to use as a framework, he did not have a statistics background and so I felt that we floundered many times. Having considerably broadened his conception of statistics as our discussions progressed, he would often bring me back to earth when we digressed by quipping 'mean, mode and median'. This may help to explain why I have now developed an interest in the study of variation and the lack of attention that it has received.

By the time I was well into the data collection and analysis stage my supervisor had been relocated to the Armidale College of Advanced Education (the old Teachers College), where teacher training was centred. It was not always easy to find the time to devote to my data analysis whilst trying to hold down a fulltime teaching job, raise a son and play sport - I guess just generally trying to have a life. Although small chunks of time could be grabbed here and there, any reasonable length of time needed to really coalesce one's thoughts was difficult to find. Writing up the study was a little easier, except that you always have this underlying fear that it will never be quite right. During this time my supervisor moved again, this time out to his present location in the Faculty of Education, Health and Professional Studies at UNE.

During all this time I had contact with my supervisor only and at one stage a Master's level class of his which was studying SOLO. I never attended, or presented at, conferences or had contact with other statistics education researchers. At the time I was not aware that this was a problem and have only more recently realized what a great benefit such contact would have been.

Fortunately, or unfortunately, extensions of time were granted whenever submission time loomed. It was only the threat of having to pay another year of fees which finally made me submit, eight years after I initially enrolled. I dedicated my PhD to my poor, long suffering, son, then 18, who had never known a year of his life when I was not studying. It is rather ironic that the only time I was not working for the University was when I was trying to study for a PhD and would have most benefited from being in a University environment.

I continue to live an isolated academic life physically, despite taking up a job at UNE on completion of my PhD. I was actually hired into the Faculty of Education, Health and Professional Studies but my role is to teach about information technology in both pre-service and in-service courses, not an atmosphere which allows too much time for statistics education research. Although this does not allow as much regular contact with researchers as I would like, the use of Information Technology and attendance at conferences and presentation of papers does provide the potential for such much needed contact.

Contact with other researchers in the field of interest, not just PhD supervisor(s), is essential. Those now embarking on PhD programs should ensure that they take advantage of every possible opportunity to attend conferences, workshops and discussion groups and publish papers. Reflecting on my own experience the biggest regret that I have is the lack of contact with other researchers, which resulted from not being amongst a group of statistics education researchers, an isolation that prevented me from sharing ideas with others working in a similar area. Not all statistics education researchers in Australia are in the same isolated position as I found myself when I was studying for my PhD. There are various research projects which are being undertaken and my advice to prospective candidates would be to ensure closer contact with other statistics education researchers during the entire PhD experience as this will help to give you a more varied perspective on your research findings and interpretation.

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10. STATISTICAL SUPPORT SERVICE FOR RESEARCHERS AT SOUTH BANK UNIVERSITY

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Researchers usually complete their degree programmes by studying a variety of units related to their respective subject discipline. When new researchers take up a post of researching a particular area of interest there are very few, if any, modules or help programmes set up to aid them in their investigation, none more so than with Statistics Education Researchers (SER). Some institutions have recognised a need for and do provide some sessions on various issues, for example on questionnaire design or survey methods. However, this is by no means enough to help the researchers with the statistics they may need in order to collect or analyse data. At South Bank University (SBU) a Statistical Support Service (SSS) is provided to help these researchers with their investigations. SER need help with statistics but also in pedagogical issues that surround the subject matter.

Setting up and running any support service demands a considerable amount of investigation and co-ordination by the organiser(s). The SSS described in this paper was set up after a great deal of discussion and planning had been carried out by me as the organiser and director. A number of factors needed to be taken into account when designing the structure for this support service. For example, one of the important considerations is that a pool of well-qualified and experienced staff is available, and such staff were indeed essential for the smooth introduction and subsequent running of the service.

The Statistical Support Service, launched in March 1999 at South Bank University, aims to provide researchers, lecturers and students with short courses in statistics and data analysis and to give on-going support to these interested parties. The emphasis is on the researchers and their research requirements and support. SER have an extra requirement of using statistics to make recommendations on teaching and learning issues. Research in statistics education is a very new subject discipline and hence the SSS has incorporated sessions related to this emerging discipline.The Statistical Support Service forms part of the Learning and Development Centre (LDC) at South Bank University. Its subject reference point is the Mathematics Support Section of the LDC. The researchers, SER, lecturers and students have not appeared to mind the Statistical Support Service being part of the Mathematics Support Section, hence its introduction and implementation has got off to a good start. Teams of statistical staff are available to give help and advice to all concerned. The main users of this service are researchers with potential data to collect and analyse, although during the last 6 months more enquiries from SER and issues related to statistics teaching pedagogy have become more prevalent.

The problems associated with providing a service of this type are numerous. Having experienced staff on hand to be able to answer the poignant questions is essential. Where these staff come from or have gained their expertise is open to debate in the UK since few statistics degree programmes are being run at the universities and hence the pool of qualified staff is ever diminishing. Staff who can help the SER are even more difficult to find. There could be a real problem in the future when trying to recruit appropriate staff. This is where the new *Statistics Education Research Journal*, in my opinion, can find a real niche hold.

Relevant and up to date handouts explaining techniques are useful for a researcher to work through but generally do not provide enough in depth material and analysis to cover all the areas of researchers' needs. At SBU we do offer certain taught classes on measures of dispersion and hypothesis testing and general survey methods. The researchers and SER then need to formulate their own plans for data collection and subsequent analysis.

The question of on-going support must be addressed and is also an essential requirement of the researcher.

In addition the SER have to be fully conversant with teaching pedagogy as well as learning and assessment techniques. The researcher or SER may have a supervisor who has relevant statistical knowledge, but in most cases, from SBU experience, this is not so and the researchers or SER come to use the service provided by the SSS. This support, while of benefit to the researcher, is not without a cost implication. The salary of the person providing support, and having someone experienced and available at the time required by the researcher are often problems. The SSS at SBU is only provided at certain times and the users of the service have to book an available time slot to obtain help. Much as we at SBU would like to provide this support continuously this is not practical in economic terms.

Relevant software is available for use but the machines that run this software are not housed in the LDC. Hence the researcher or SER must print out any query they have and bring to the SSS. Our computer services department will help with the problems associated with the computers but do not necessarily have the expertise in the software package being used. Some researchers, particularly if they are not fully computer literate, can find this a real stumbling block. Our staff in the SSS have on occasions gone to the computer lab with the researcher needing help. For any new software, i.e. not the general statistical software that is generally used such as SPSS or Minitab, our SSS staff may not be familiar with all the technical details and hence can waste a lot of time on something that is not of a statistical nature. Our experience at SBU is that researchers and SER often embark on a piece of statistical analysis without first considering the questions shown in Figure 1. We use these questions as a basic crib sheet to make sure the researchers and SER have fully thought out their investigations. The questions were originally designed for students doing statistical projects in the UK by the Centre for Statistical Education (Rangecroft et al 1996). While this may sound very trivial to experienced researchers/ statisticians we have found it a useful starting point and it leads onto more in-depth discussions about the investigations.

1. What exactly am I trying to find out?
2. Who or what do I want to find out?
3. What sort of information will I collect?
4. How shall I collect my data?
5. What should I include on my data collection sheet or questionnaire?
6. How long do I have to complete this project?
7. How should I choose my sample?
8. What resources do I have?
9. How accurate must my results be?
10. How big a sample should I choose?
11. How will I analyse my findings?
12. How will I collect together the answers?
13. How do I present my findings?

Figure 1: Questions to be addressed before starting your investigation

While I have outlined the problems we have found here at SBU and that any organisation attempting to provide this type of service should be aware of, the SSS has received good reports form the people that have used the system. We at SBU will continue to offer this service and hope to extend its provision in the next academic year. Should you need any further information or can offer any help regarding our service at SBU then please feel free to contact me.

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THE INTERNATIONAL RESEARCH FORUMS ON STATISTICAL REASONING, THINKING AND LITERACY: SUMMARIES OF PRESENTATIONS AT STRL-2[(1)]

SUMMARY

This report includes a brief introduction to the Statistical Reasoning, Thinking and Literacy (SRTL) Research Forum Program, an overview of SRTL-2 and STRL-3, and summaries of each of the SRTL-2 presentations.

Keywords: *statistics education, SRTL forum, statistics, reasoning, thinking, literacy.*

1. INTRODUCTION

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1.1. THE SRTL RESEARCH FORUM PROGRAM IS BORN

The International Conferences on the Teaching of Statistics (ICOTS), held every four years, beginning in 1982, helped to progressively link an informal research network of people interested in carrying out research on the teaching and learning of statistics at all age levels. Several papers at ICOTS-5, held in June 1998 in Singapore, focused on the related topics of Statistical Reasoning, Statistical Thinking, and Statistical Literacy. Discussions about these papers and the need to distinguish between the terms "literacy", "reasoning" and "thinking" led to the First International Research Forum on Statistical Reasoning, Thinking and Literacy (SRTL-1) which was held in Israel in July of 1999.

In July of 1999, sixteen statistics educators from six different countries met for five days at Kibbutz Be'eri in Israel to discuss the topics of statistical literacy, reasoning, and thinking. The Forum was co-chaired by Joan Garfield (University of Minnesota, USA) and Dani Ben-Zvi (Weizmann Institute of Science, Israel). One unique feature of this Forum was the use of videos of classroom work or interviews with students, as a way to present, discuss and argue about research related to these topics. Sponsors of SRTL-1 were the International Study Group for Research on Learning Probability and Statistics, the International Association for Statistics Education, the University of Minnesota, the Maurice and Gabriela Goldschleger Conference Foundation at the Weizmann Institute of Science, and Kibbutz Be'eri.

Discussions and research at this first forum revolved around a number of issues. An attempt was made to clarify what constitutes statistical reasoning, thinking and literacy (SRTL), how are these cognitive processes and/or outcomes different and how are they related? In particular, the first forum aimed to address the following questions:

- What does research on SRTL tell us about the learning and teaching of statistics? What are the cognitive, socio-cognitive, or developmental aspects of learning SRTL in different age/grade levels?
- What theoretical frameworks and methodologies are appropriate for researching SRTL?
- What types of qualitative and quantitative research studies are needed to help us better understand these ways of processing information and to help promote them in educational settings? Particularly, how do we collect, use and analyse video material for research on SRTL?
- What are the implications of research into SRTL for learning goals, curriculum design, and assessment?

Participants were asked to bring video clips and transcripts to illustrate different types of statistical literacy, reasoning and thinking. The group met all together to view videos and discuss the various research projects. SRTL-1 was a first attempt to focus a research forum on the interrelated and often poorly defined topics of statistical literacy, reasoning, and thinking. Participants of SRTL-1 indicated that the meeting's format enabled good discussion, and that it was stimulating and enriching to become acquainted with key researchers in this area

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[(1)] *Statistics Education Research Journal 1(1), 30-45, http:/fehps.une.edu.au/serj*
International Association for Statistical Education

and to view their work in progress. Many especially valued the small size that allowed plenty of time for interaction and discussion, the use of video in the talks and the extended discussions of videotaped sequences.

It was clear from participants' evaluations that this was only the beginning of a very exciting and promising line of research, and that there was much work to be done, so a second gathering (SRTL-2) was planned in Australia, with a similar format but improved structure.

1.2. SRTL-2 - ARMIDALE - 2001

The Second International Research Forum on Statistical Reasoning, Thinking and Literacy (SRTL-2) was held at the University of New England (UNE), in Armidale, Australia from August 15 to August 20, 2001. The Forum was co-chaired by Joan Garfield (University of Minnesota, USA), Dani Ben-Zvi (Weizmann Institute of Science, Israel) and Chris Reading (University of New England, Australia). Just prior to SRTL-2 Bob delMas (University of Minnesota, USA) kindly agreed to also co-chair when Joan Garfield was prevented from coming to Australia due to poor health. Sponsors of the Forum were The IASE Statistical Education Research Group (IASE-SERG), The Centre for Cognition Research in Learning and Teaching (UNE), The School of Curriculum Studies (UNE), the Faculty of Education, Health and Professional Studies (UNE), and The Department of Educational Psychology (The University of Minnesota).

This was a unique opportunity for twenty researchers from six countries to meet for six days to share their work, discuss important issues, and initiate collaborative projects. For the first three days participants were divided into four small working groups, each with three or four presentations and one discussant. The research presented focused on the challenges in describing, teaching, and assessing statistical reasoning, thinking, and literacy, with the emphasis on reasoning. Most presentations included data presented on short videotape or audiotape. The next two days included sharing a synopsis of group findings with all participants and a discussion of the implications of the research presented. A panel session, with four invited speakers, entitled 'what we can learn from mathematics education research' on the final day was followed by an evaluation session and planning for SRTL-3. Following is a summary of the various sessions in the scientific program.

1.3. SRTL-3

SRTL-2 concluded with an evaluation session and discussion on future directions. Plans are now underway for the staging of SRTL-3. It is anticipated that this International Research Forum will be held in August 2003 in Lincoln, Nebraska. Dani Ben-Zvi and Joan Garfield are currently working on an edited book of research papers, some of which were presented at SRTL-2. For more information about SRTL please visit the website at http://www.beeri.org.il/srtl.

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2. REASONING ABOUT DATA AND DISTRIBUTION THROUGH THE STATISTICAL INVESTIGATIONS OF A THIRD GRADE CLASSROOM

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We contend that statistical reasoning occurs in the context of applying the process of statistical investigation to solve a specific problem or better understand a topic. In particular, this entails utilizing statistical ideas and information as well as presenting or summarizing data in meaningful ways so that inferences or interpretations from the data can be made that lead to greater understanding about the topic of the investigation. In this session, we gave a description of a third grade teacher's reasoning with data through graphs in the context of applied statistical investigations. The teacher attempted to thematically use the process of statistical investigation as a tool to teach other k-6 curriculum topics, such as language arts, social studies, health and science. We discussed what this reasoning looks like in the elementary classroom, how it is used, and why it is important to study.

The participating third grade teacher took part in a professional development workshop on the process of statistical investigation and the development of curriculum merging this perspective with elementary curriculum topics in Summer 2000. The participating teacher in this study was a best case scenario in that the teacher had considerable prior experience with statistics through a local implementation of Quantitative Literacy and the American Statistical Association's project competitions. The object of our investigation was the teacher's knowledge about data and distribution in the context of teaching during the school year following the summer workshop. An open-ended, hands off approach was used to observe teaching practice. All subsequent interventions regarding statistical content were made after a teaching episode in response to teacher questions. The statistical investigation units were planned in advance and video-taped by researchers in the elementary classroom.

Five artifacts on classroom teaching with supporting video were shared to illustrate the contextual features influencing statistical reasoning in the context of applied statistical investigations into topics across the third grade curriculum. We found our group's discussion and interaction with our data extremely valuable. Three main ideas were raised in the discussion of our data that point to the need to focus on pedagogical content knowledge in teaching statistical investigation.

The first idea focused on the relationship between questions posed, data collected and the purpose of the investigation. The pressing question was: "when should the teacher and children consider the investigation question in the process of reasoning with data?" One perspective presented is that one ought to consider the question in the planning phase of an investigation, then with the question in mind proceed to think through the data collection process. Another perspective argued that one should simply gather data without a pre-planned purpose in mind and then ask what is the data telling me now?

The second idea centred on the role of central tendency and variability, in making interpretations, inferences and predictions based on data. We repeatedly saw the teacher and children interpret data based on frequency of occurrence, in terms of which group had more and which had less. There was little/no evidence of the teacher or children using variability in their interpretations, inferences or prediction. Considering the interplay of central tendency, variability, interpretation and prediction, and the underlying story from the data raises interesting questions about the nature of learning opportunities offered and possibly missed. In regards to these first two ideas, it was pointed out during discussion that when teachers do not know or understand the content sufficiently well, they fall back to a comfortable position in terms of what they do know. In the case of teaching and implementing a statistical investigation in the classroom, we repeatedly saw this phenomenon where the nature of the posed investigation questions were of the type which group has more versus which has less, and the sole use counts as a means to analyse data.

In the process of reasoning with data, our teacher naturally attempts discussions on interpretations of data. When one looks closely at the dialogue, it is apparent that the teacher does the talking, asks the questions (usually with particular answers in mind), tries to lead students to specific answers, but often answers her own questions. This observation raises interesting questions about the interplay between this teacher's knowledge of statistics and her ability to be fluent in the different ways she might want to be, or need to be, responsive to students' learning needs. A related research question that was generated is: In what ways does the teacher's statistical knowledge influence his/her manner of leading class discussions with children? We left our session with new insights for further data analysis.

From the analysis we have done so far, we can say that it is extremely difficult to make a judgement about a teacher's statistical reasoning by looking in isolation at their understanding of statistical concepts like distribution, centre, and spread. In other words, knowing that a teacher knows how to pose a question, collect data, and summarize the data graphically does not necessarily predict what the teacher will be like in the classroom, teaching the process of statistical investigation in an applied context. The teacher in this study was a 'best case' scenario since she had previous statistics experience in a number of different contexts, and had demonstrated more than a sufficient command of the statistics in a de-contextualised situation removed from the immediate act of teaching (i.e. the summer workshop). In one sense she knows the content, however, we continually see the limits of what she knows or how she knows it when she tries to use the knowledge in teaching to help children learn the same ideas about statistical reasoning.

Our case highlights the need to understand the differences between statistical content knowledge and pedagogical content knowledge in statistics when conducting applied statistical investigations. What the data analysis session at SRTL-II did for us is begin to define in greater detail what pedagogical content knowledge in statistics is needed when working with K-6 teachers.

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2. STATISTICAL INVESTIGATIONS: YEAR 7 AND 8 STUDENTS' REASONING WITH MULTIVARIATE DATA

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The 4-dimensional framework for statistical thinking in empirical enquiry created by Wild and Pfannkuch (1999) provided the theoretical model for examining and describing students' reasoning with data. This model was built up through examining the statistics discipline itself and can be thought of as a way of describing the type of thinking that should be fostered in students. Some interviews with 11 and 12 year-olds (Rubick, 2000), while conducting their own statistical investigation with a small multivariate data-set created by Watson, Collis, Callingham and Moritz (1995), were presented as well as the students' written tables, graphs and conclusions.

The data were analysed through the four lens of transnumeration, consideration of variation, reasoning with statistical models and integrating the statistical with the contextual (Yoon, 2001). These four aspects were identified in the Wild and Pfannkuch framework as being fundamental types of statistical thinking. The analysis of the data attempted to describe the students' reasoning through these four lens. For example, data were provided to demonstrate students' noticing local and global variation, explaining local and global variation, controlling variation and quantifying variation. All these data showed students' emergent understandings of variation.

The following four aspects were highlighted as a result of group discussion about the data presented. First that students' views of data throughout a statistical investigation involve not only an intertwinement of local and global statistical thinking but also an intertwinement of local and global contextual thinking. Second that students created their own representations for displaying multivariate data which seemed to be fostering statistical thinking and seemed to be part of learning how to represent data. Third that developing an awareness of the need to converse with the data as well as to have different conversations with data in their various representations is part of the reasoning process throughout an investigation. These conversations build up an understanding of relationships in a data-set and enable students to learn more in the context sphere. Four that students need to play the dual role of corroborator and discoverer. The corroborator uses data to justify a claim whereas the discoverer is the explorer or data-detective or hypothesis generator who looks at data for possible interesting patterns, features, anomalies and so forth.

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4. JUNIOR HIGH SCHOOL STUDENTS' CONSTRUCTION OF GLOBAL VIEWS OF DATA AND DATA REPRESENTATIONS

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Becoming competent in a complex subject matter domain, such as statistics, "*may be as much a matter of acquiring the habits and dispositions of interpretation and sense making as of acquiring any particular set of skills, strategies, or knowledge*" (Resnick, 1988, p. 58). This involves both cognitive development and 'socialization processes' into the culture and values of 'doing statistics' ('*enculturation*'). This study of Ben-Zvi & Arcavi (2001) is intended as a contribution to the understanding of these processes in the area of Exploratory Data Analysis (EDA). It focuses on the ways in which junior high school students begin to develop a global view of data and their representations, while investigating time series.

Data were collected in a progressive experimental school during a 10-week EDA course: 1) videotapes of one pair of seventh grade students capturing their learning during the first four class periods; and 2) responses of 80 students – working in pairs and using a spreadsheet – to a data analysis assessment task, which was administered after the end of the EDA course. The analysis of the videotapes was based on *interpretive microanalysis*: a qualitative detailed analysis of the protocols, taking into account verbal, gestural and symbolic actions within the situations in which they occurred. The goal of such an analysis is to infer and trace the development of cognitive structures and the socio-cultural processes of understanding and learning. The data of the assessment task were categorized and analysed taking into account the type of explanations associated with them.

This study shows how students' novice views slowly changed and evolved towards an expert perspective by making use of local information in different ways as stepping-stones towards the development of global points of view of data sets in different representations. At the beginning they persistently emphasized local views of data in tables and graphs. They were attentive to the prominence of 'local deviations', which kept them from dealing more freely with global views of data. Only later, the focus on certain point wise observations, the gradual adoption of the notion of *trend*, and the exercise of scaling, helped them to direct their attention to the shape of the graph as a whole, taking into account the variability in the data.

Students' learning involves: a) prior knowledge is engaged in multifaceted and sometimes unexpected ways – possibly hindering progress in some instances, but making the basis for construction of new knowledge in others; b) during the learning process, many questions either make little sense, or, alternatively, are interpreted and answered differently from the original intention; c) students' work is inevitably based on partial understandings, which grow and evolve towards more complete meanings; d) most of the learning takes place through dialogues between the students themselves and in conversations with the teacher; and e) sophistication in students' understanding of data develops within each point of view (local and global) and within the dynamic and flexible integration of those views.

This study confirms that even if students initially do not make more than partial sense of their data analysis tasks, through the support of appropriate teacher guidance, class discussions, peer work and interactions, and ongoing cycles of experiences with realistic problem situations, students slowly build meanings and develop experts' points of view on local-global approaches to data and data representations.

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5. FROM DATA VIA 'BUMP' TO DISTRIBUTION

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Students tend to see data as individual values and find it hard to reason with data sets as a whole that has certain characteristics such as an average representing the group, a majority and outliers, or a constant shape. An end goal of our teaching experiments was therefore that students could reason with distributions on an intuitive level in relation to shape (hill, bump). For this classroom-based research in six seventh-grade classes, the so-called statistical minitools initially designed by Cobb, Gravemeijer, and colleagues of the Vanderbilt University (Cobb et al 1997) were used.

At the presentation, three episodes were discussed. The first video fragment showed how students found the mean visually in a value bar graph by a compensation strategy (figure 1). Student: *"I cut off the long bits and give them to the shorter ones"*. The presenter argued in the discussion that this representation is more suitable for developing understanding of the mean than the balance model.

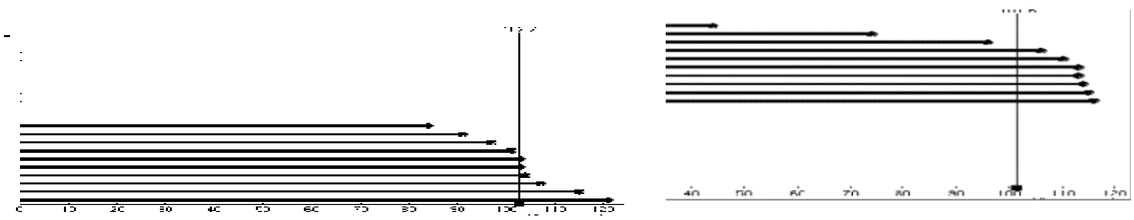

Figure 1. Compensation strategy on battery life span data in hours.

The second video fragment was an example of what the presenter calls 'extended sampling' or 'growing samples'. Students investigated sample size starting with four data points and adding new data to it up to 67 data points with dot plots. After that they predicted the shape of still larger samples. Their predictions were smoother and more hill-like than the investigated dot plots from smaller samples. In the last episode, students started to reason with 'bumps' after student-made graphs had been discussed. They predicted shapes and used terms like majority, outliers, sample size to explain their predictions.

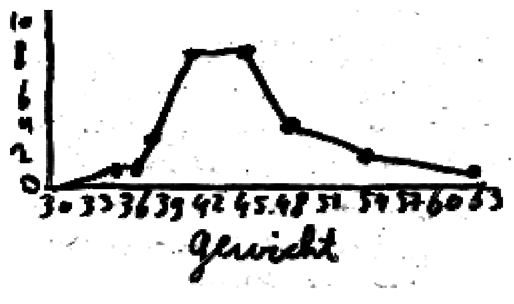

Figure 2. Student graph of weight in kg leading to discussion of' bumps'.

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6. 'VARIATION' FROM A STUDENT'S PERSPECTIVE

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As statistics is the methodology needed to make decisions under uncertainty and variation is the source of this uncertainty, the understanding and analysis of variation is critical to students' reasoning in statistics. Although a number of global questions were posed relating to how students dealt with variation in different situations and some factors affecting their responses, the two questions deal with in most detail were: How is this variation described by students? and Is there an hierarchy of understanding of variation?

During the session a variety of student responses, which had been collected from a number of different sources, were used to help build up a Matrix of Description and Understanding of Variation (summarized in Table 1). This matrix, which gradually unfolded as the session progressed, is only in an embryonic form with no column headings as yet. The student responses, in italics, may help to elaborate on the titles of each cell in the matrix.

First, examples of the language used by students when asked to describe variation in general terms were examined and allocated to three cells forming the beginning of the matrix. Second, examples of any variation-related aspects of responses to open-ended general questions in various areas of statistics were presented and added to the matrix, creating some new cells. Third, variation-related aspects of student responses to a variation in sampling problem were slotted into the matrix. Fourth, and final, video excerpts of students working on the same sampling problem, but in a small group situation, were viewed and appropriate response segments added to the matrix.

Table 1. Summary of suggested Matrix of Description and Understanding of Variation

SUBSTITUTE ANOTHER WORD different changing variety	MOVE FROM ONE VALUE TO THE NEXT drop or go higher from high to low and back up again	IDENTIFY EXTRANEOUS SOURCE OF VARIATION I might get less than my friends might pick all over the place
CONCERN WITH MIDDLE VALUES size of the numbers doesn't matter just have to be different	CONCERN WITH EXTREMES minimum and maximum varies from 2- 7 stay out of the extremes	INDIRECTLY IDENTIFY SOURCE OF VARIATION not pick 7 – have got other colours in there
LOOK FOR A PATTERN no regular eating habits overall are gradually increasing	CONCERN WITH EXTREMES AND WHAT HAPPENS BETWEEN most …and least …and on average …	DIRECTLY IDENTIFY SOURCE OF VARIATION depends on what day it is for different ages
	DISCUSS CHANGE COMPARED TO SOMETHING come close to most of the non-extreme values	
	DISCUSS CHANGE COMPARED TO 'CENTRE' VALUE average around half…go over occasionally	

Discussion then centred on the various categories in the matrix and possibilities for rearrangements and headings for the various columns but no definite conclusions were reached. However, the student responses presented did demonstrate some aspects of students' describing variation and the matrix should help to provide a basis for developing an hierarchy of understanding of variation.

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7. ASPECTS OF STUDENTS' UNDERSTANDINGS OF VARIATION

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A repeated samples task and a probability task were presented to mathematics students in both written and interview format in order to study students' thinking and reasoning in contexts where repetitions of experiments lead to variation in the results of the trials. Over 300 middle level and secondary level students (predominantly ages 12 – 16) were given a survey to explore their thinking. Students predicted outcomes from a series of repetitions of the sampling activity and of the probability task. They were then asked to explain their reasoning, why they thought the results would occur as they predicted. Student responses to the written survey led to the development of an interview script for each of the two tasks in order to more explicitly address some of the issues that were surfacing in the written task. Audio taped interviews were conducted with 24 secondary school mathematics students.

Results indicated that a variety of types of thinking arise among students who are given such tasks to tap their conceptions of variation, including either too narrow or two wide an expectation for the range of results in the distribution of data from repeated samples. This session also shared evidence of students' beliefs about how they feel repeated experiments "should" come out, about their confidence or lack of confidence in predicting the results of sampling experiments. A necessary, but possibly not sufficient condition for students to make good predictions about repeated trials of a probability experiment is accurate knowledge about the sample space. Students may actually be able to list all possible outcomes prior to conducting experimental trials, or they might "learn" what the sample space is *while* conducting trials, but in either case knowledge of the sample space is critical for making reasonable predictions. Similarly, an understanding of what would be a *reasonable* spread around the population mean--some intuitive understanding of a confidence interval--is necessary for making good predictions for the results of repeated samples from a known population.

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8. COMPARING TWO DATA SETS: REASONING AND THE INFLUENCE OF COGNITIVE CONFLICT

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This research looked specifically at school students' reasoning associated with comparing two data sets presented in graphical form. Of particular interest were comparisons where the data sets are of the same or different size. The reasoning was shown in the arguments presented by students to show that one or the other data set represents a class that had performed "better" on a test. As well many students were shown conflicting arguments of other students (on digital video) and asked to choose between the other student's argument and their own. Again arguments were documented and final decisions noted.

Individual interviews were conducted with 60 students from four Tasmanian government schools: 10 third- and sixth-grade students from each of two primary schools, and 10 ninth-grade students from each of two secondary schools. Students were selected on the basis that they would be willing to talk in interview and not be threatened by the complexity of listening to other students' ideas and evaluating them. Hence it might be expected that the students interviewed were more willing and able than would normally be expected for their grade levels. All interviews were video taped.

Following the data collection of Watson and Moritz (1999), a digitised video clip research resource was created using selected student responses from the 88 student interviews. The objective was to present new students being interviewed with conflicting ideas selected from interviews with the earlier 88, mimicking to some extent an ideal classroom setting where students engage in dialogue and debate. Eight prompts were included in the final protocol.

Among the research questions considered was the following: What is the evidence for visual strategies used in comparing the variation between data sets; is it based on individual attributes of the sets or on features across the entire sets; and do the strategies change after prompting? A clustering technique used on the responses produced five categories of increasing complexity of argument in using the visual evidence in the graphs, both when the size of the two sets was the same and when the size was different. Examples from the categories were given based on the video extracts of the students explaining their reasoning.

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9. COMPARING TWO DISTRIBUTIONS: INVESTIGATING SECONDARY TEACHERS' STATISTICAL THINKING

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While many schools are increasing their emphasis on statistics, few are taking the necessary steps to help teachers master the statistics they are expected to teach. Furthermore, U.S. teachers have little experience with data analysis and inferential statistics, yet in an era of accountability, are required to make instructional decisions based on large quantities of data about their students' performance.

Texas, where the study took place, has a high-stakes accountability system. Students are tested annually with the Texas Assessment of Academic Skills (TAAS), and high school graduation depends on passing this test. In addition, schools and teachers are held accountable for their students' performances. In this climate of high stakes accountability, urban schools that serve less academically advantaged children are under constant scrutiny to ensure they do not receive unacceptable ratings. As a result, much of the schools' professional development time is spent focusing on their TAAS results. Teachers feel that the accountability system creates a situation over which they feel very little power. This context seemed ripe to invite teachers to examine the statistical data as investigators.

A research team at The Systemic Research Collaborative for Education in Mathematics, Science, and Technology (SYRCE) in the College of Education at the University of Texas – Austin designed the NSF-funded research. Our focus group in the project was the mathematics department at our partner school, an urban middle school that feeds into a low-performing high school in the district. The professional development workshops followed an immersion model, allowing teachers to *do* statistics by investigating their own questions, and was conceived as a mathematical parallel of the Writers Workshop from the National Writing Project, where teachers learn to write rather than how to teach writing. The research project had a set of four related objectives to: (1) Strengthen *teacher content knowledge in statistics* by giving them the opportunity to learn statistics well beyond their curriculum; (2) Immerse teachers in *focused investigation and chains of reasoning* about student data in a high-stakes accountability environment; (3) Build *teacher confidence and facility in using dynamic software* (*Fathom*); (4) Orient teachers with a *healthy mindset about data and inquiry*: the acceptance of uncertainty when searching for solutions, the limitations and misuses of statistics and inferential reasoning.

The project took place in Spring and Summer 2001. During the spring, teachers learned the basics of the software *Fathom*™, unique in its application as a teaching and inquiry tool. Also during the early stages of our interactions with teachers, we examined introductory descriptive statistics and became acquainted with their student data. Throughout the latter phase of the project, a two-week intensive summer institute, teachers built a richer conceptual understanding of sampling distributions and inference through discussion, problem-based investigations with their student data, and simulations using *Fathom*. Sampling distributions were used frequently in problems to provide evidence for differences in groups and to imbue a tolerance for variation. As the study progressed, increasing amounts of time were dedicated to the teachers' own explorations. During the second week of the summer institute, teachers investigated a problem of their own choosing and presented their findings on the final day of the project to their peers and a group of researchers. At this time, clinical interviews were conducted to further probe teachers' reasoning about group comparisons. Our particular interest was in inquiry surrounding the question: How do you decide if two groups are different?

In the SRTL2 presentation, the videoed responses of four teachers in a clinical interview were examined. In the interview, which followed the project, teachers were asked to compare the relative performances of males and females on the state competency exam, given raw test scores for each group. Beyond the computational distinction made through descriptive statistics, teachers' analysis of comparing two groups was examined using several other important concepts: *tolerance for variability*, *understanding of the context*, and an ability to *draw conclusions*, perhaps inferentially. A categorization for statistical thinking about comparing two groups was described with five levels of reasoning that teachers use when comparing two groups.

Feedback during the presentation revealed commonalities with other areas of research in the focus group. Interestingly, the four members of the focus group (Jones, Moritz, Biehler, and Makar) represented research covering four different age levels: lower primary, upper primary and middle school, upper secondary, and professional; yet every age level struggled with similar concepts: understanding graphical representations and their connection to context, and conceptualizing variation.

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10. CONFLICTING REPRESENTATIONS OF STATISTICAL ASSOCIATION

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10.1. BACKGROUND

Social- and physical-sciences often aim to reach verbal conclusions of causation by collecting bivariate data that involve statistical association and by controlling for other variables. It is important to be aware of the translation processes among raw numerical data, graphical representations, and verbal summaries, and an understanding of what constitutes a statistical association when presented in these forms (Fig. 1).

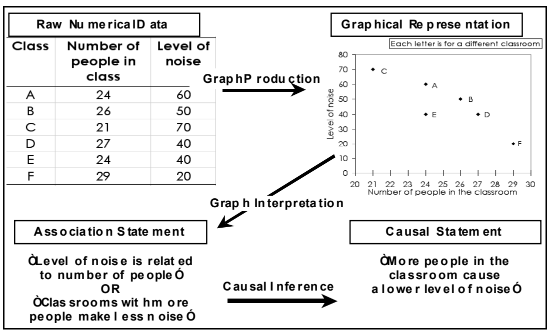

Figure 1. Forms of representing statistical association and skills of correlational reasoning to translate them.

10.2. TASKS

Students were provided with brief contexts of data collection involving at least two variables, and were given verbal statements of association to represent graphically:

Q1(a). "People grow taller as they get older".

Q1(b). "People do grow taller. But when you are 20 years old, you stop growing".

Q1(c). "For 10 year olds, girls and boys are about the same height. But men usually grow to be taller than women."

Q2. "People who studied for more time got lower scores."

Q3. "An almost perfect relationship between the increase in heart deaths and the increase in use of motor vehicles".

These tasks were intended be more informative of student understanding of association than asking students to judge whether a given graph represents an association. Q1 was based on Mevarech and Kramarsky (1997) who observed students' difficulties with linear relation of zero slopes.

10.3. SURVEY RESPONSES

Responses from previous research have been coded into 3 levels for Q1 (Moritz, 2000) and 4 levels for Q3 (Moritz & Watson, 2002). For this study, a total of 184 student surveys (grades 3, 5, 7, and 9) were gathered. Coding responses to Q2 was discussed with respect to causal reasoning about the topic context and beliefs about the direction of the association (see Figure 2).

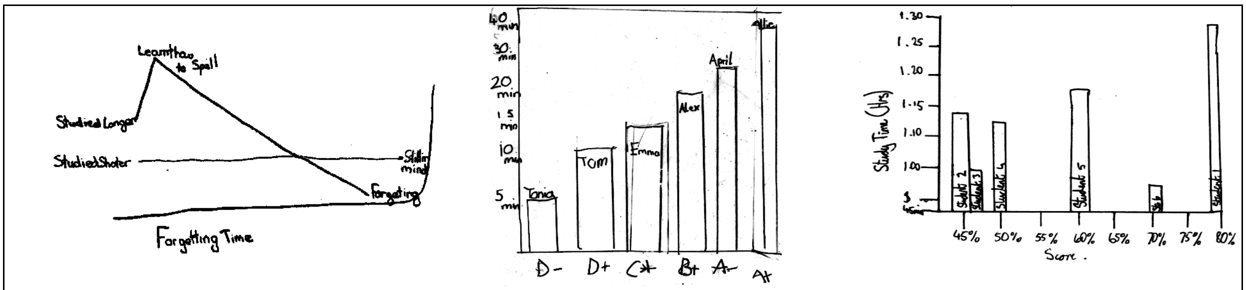

Figure 2. Student responses to Q2: (left) causal, grade 7; (middle) direction, grade 5; (right) direction, grade 7.

10.4. INTERVIEW DIALOGUE

In videotaped individual interviews, 34 students in grades 3, 5, 7, and 9 were first asked to explain their graphs, in particular how the graphs show the information and why they chose to represent the verbal statement the way they did. In an attempt to create cognitive conflict to explore how students might learn from new ideas, interviewees then were shown graphs drawn by other students, and asked to compare the different responses to decide which better represented the verbal statement. Selected extracts of dialogue illustrated how some students ignored the specifications of the survey task in order to represent what they believed about the topic context.

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11. DEVELOPING AND ASSESSING STUDENTS' REASONING IN COMPARING STATISTICAL DISTRIBUTIONS IN COMPUTER SUPPORTED STATISTICS COURSES

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The paper summarizes results from some of our studies of students' reasoning with data. We interviewed students after a computer supported course in statistics, which had an emphasis on exploratory data analysis (EDA). Our major goal was to support students' thinking in terms of "distributions". One of the issues we looked at was strategies and tools students used for comparing two data sets. Students had learned various displays and summaries including dot plots, box plots, histograms, mean, median, quartiles, interquartile range, variance and standard deviation.

We consider a cultural practice of using just means for group comparison as critical and often misleading. The origin of EDA is closely related to this criticism. Before one uses certain summary statistics for comparisons, distributional assumptions have to be checked, data displays have to be used for becoming aware of distributional behaviour. Box plots were introduced as an exploratory tool which provide a multifaceted initial distributional summary including a robust measure of the center and information about the amount of spread above and below the center. The difference :

$$q_3 - \tilde{x} = median\left(x_i - \tilde{x} \mid i \geq \frac{n+1}{2} \right)$$

where $\tilde{x}$ is the median of the whole data set can be interpreted as an average deviation from the median in the upper half (similarly the difference $\tilde{x} - q_1$). In this sense the box plot is intended a center ± spread display. In our research we identified many "non-standard" uses of box plots.

Students often frame group comparison tasks as hypothesis testing tasks such as: *Is X larger in group 1 than in group 2?* Example: Do boys (tend to) watch longer TV per week than girls? The expectation that this question has a definite answer is one of the obstacles that have to be overcome. Students are looking for a single comparison number, are irritated when quantiles in the box plot do not all point into the same direction. An interpretation of quartiles as medians of the lower (upper) half that could help is often not available. Students have difficulties in relating spread information to aspects of the context of the data. We think that the conscious introduction of the "uniform shift model"(group 2 distribution is just group 1 distribution uniformly shifted by a fixed amount) might help students. Looking for deviations from a shift model can draw attention to more complex distributional relation can occur.

Some students interpret the box as representing the "majority" of the data although it contains only 50%. The quantiles of the box plot are used for quantile by quantile comparisons but students do not understand why only this quantile selection. The quantile comparison of distributions was introduced by Galton and we consider this use as different from the use intended in EDA. Other students can see the varying data density in a box plot and can relate this to the different density representation in a histogram. It seems however to be difficult to see the box plot as a center± spread display at the same time.

Generally, group comparisons need much more conceptual underpinnings than usual courses seem to offer (including our own). Different uses and interpretations of box plots have to be developed with adequate contexts. The presentation showed some tasks and data sets we used in order to achieve this goal. One of the formats was to ask the students to sketch the distribution in group 2 when a graph of the distribution in group 1 was given. This task opened an instructive window on students' thinking in terms of distributions and the interplay between representation and contextual knowledge.

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12. STATISTICAL REASONING USED BY ELEMENTARY AND MIDDLE SCHOOL STUDENTS WHEN THEY ANALYZE AND INTERPRET DATA

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The session focused on elementary and middle school students' statistical reasoning when they faced tasks that engage them in analysis and interpretation. Analysis and interpretation incorporates recognizing patterns, trends, and exceptions in the data and making inferences and predictions from the data. It includes what Curcio (1987) refers to as *reading the data*, *reading between the data*, and *reading beyond the data*. Hence, when observing students analyzing and interpreting data, we were interested in the following processes: (a) how they extracted and described information explicitly stated in the data (reading the data), (b) how they compared and combined data (reading beyond the data), and (c) how they made predictions from the data (reading beyond the data). Consistent with these processes, we generated clusters of tasks like the following to assess children's statistical reasoning when they analyzed and interpreted data: (a) What does the picture tell you? (describe the data) (b) Which day had the lowest number of visitors? (compare) (c) How many friends came to visit during the week? (combine) (d) About how many friends would you expect to visit during the next 4-week month? (predict).

Having established some meaning for analysis and interpretation, we looked at videotapes of individual students (Grades 1 through 6) as they engaged in tasks involving analysis and interpretation. These structured interviews revealed four hierarchical levels of statistical reasoning: idiosyncratic, transitional, quantitative and analytical. Students who exhibit *idiosyncratic* reasoning consistently focus on ideas that are unrelated to the given data and frequently focus on their own personal data banks. Students characterized as *transitional* have begun to recognize the importance of quantitative thinking and generally provide relevant but limited responses to tasks. Students who exhibit *quantitative* reasoning can analyze and interpret data from more than one perspective; however they do not make connections between different aspects of the data. Consequently, they do not detect inconsistencies in their reasoning. Students characterized as *analytical* interpret data from different perspectives and are able to make connections between different aspects of the data.

We also examined Grade 2 students' analysis and interpretation of data during a teaching experiment. Our analysis revealed that these children were able to read between the data and beyond the data under certain conditions. Context plays a key role, and by providing opportunities for children to describe and investigate themes like a butterfly garden for an extended period, the teacher was able to build up a stronger contextual background for tasks involving analysis and interpretation. Children had difficulty focusing on subsets of data and this, in turn, affected their ability to make comparisons between two subsets of data. When looking at two subsets, we found that children focused on individual data values like the mode rather than examining the data subsets as a whole.

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13. METHODS FOR ASSESSING AND RESEARCHING STUDENT REASONING ABOUT SAMPLING DISTRIBUTIONS

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The main objective of this session was to present a discussion of how we as statistics education researchers could capture statistical reasoning. What does it look like? What should be assessed? How can we assess it? Why are we assessing it? All of these questions were addressed during the session. What follows is a basic outline of our discussion. The general outcome of the session, as I anticipated, was not any new specific knowledge, but rather a set of ideas that we as researchers should consider when investigating statistical reasoning in any context.

The presentation began with a brief review of literature summarizing what other researchers have done with sampling distributions. There is a lack of consistent measurement tools used to measure "understanding" or "reasoning" about sampling distributions – each researcher has traditionally used a course quiz or exam, idiosyncratic to the class and professor. There is an obvious need for statistics education research to pursue consistent, reliable, and valid ways to measure reasoning about sampling distributions. This led the group to two questions: (a) what are we calling statistical reasoning, and (b) what are we building towards? These lead us back to the question of "how do we assess statistical reasoning?"

One discussion thread identified one of our goals as professors is to build procedural and process knowing with our students … what can they do with the knowledge they have about sampling distributions? Looking at the concept of "sampling distribution," what is it we want them to know exactly? And if we look at the behavior or actions of our students for research data, how do we identify what knowledge is behind those behaviors and actions? Is this knowledge emerging with the task in which they are engaged? Or is this knowledge already in place in their minds, and they are simply accessing and using that knowledge?

Methods of assessing statistical reasoning that we discussed included memory and recall tasks (can you tell me what this is) and image making (e.g., concept mapping). There are a variety of methods for assessing this type of relational knowledge (Jonassen, Beissner & Yacci, 1993; Olson & Biolsi, 1991; Schau & Mattern, 1997). Does each of these methods give us reliable and valid data? Are any of them transferable to classroom assessment practices? These are questions statistics education researchers need to address before we can come up with consistent and comparable results across age levels and throughout the world.

By the end of the session, the group had not looked at specific examples of data as other groups and sessions did. What we had done instead was look one-step before collecting data to evaluate (a) what data should we collect? (b) How should we collect it?, and (c) what will this data tell us about what students know, how they know it, and how they came to know it? The discussion generated many more questions that we could have possibly answered, but I believe we have set up some interesting points to ponder as we move forward in our statistics education research efforts.

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14. A FRAMEWORK FOR THE DEVELOPMENT OF STUDENTS' STATISTICAL REASONING

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At the first SRTL, held in 1999 at Kibbutz Be'eri in Israel we summarized our research data and presented our initial framework for modeling students' levels of statistical reasoning. At SRTL-2 in Australia we focused on our current attempts to use videotaped interviews with students to modify the framework and better describe students' reasoning. The presentation started with a general description of our theoretical framework, which is motivated by the work of several researchers in cognitive development (Biggs & Collis, 1982; Case, 1985; Case, Okamoto & Griffin, 1996; Jones, Langrall & Thornton, 1997). This was followed by a description of our most recent research methods, which used students enrolled in several undergraduate introductory statistics courses within both the Statistics Department of Cal Poly and two departments of the University of Minnesota, as well as a graduate course at Minnesota. The procedure involved (1) administration of a pre-test on reasoning about the behavior of sampling distributions, (2) identification of a small sub-sample of students that appear to have different levels of reasoning, and (3) videotaping interviews with these students as they worked on problems designed to probe their reasoning about sampling distributions.

Our current analysis of the interviews attempts to identify aspects of students reasoning in order to more fully describe students thinking. Currently we have identified six categories of students' reasoning about sampling distributions:

- *Fluency*: Understanding and appropriate use of terms, concepts, and procedures
- *Rules:* Identification and use of a rule for prediction or explanation
- *Consistency:* Presence or absence of contradictory statements
- *Integration:* Extent to which ideas, concepts, and procedures are connected
- *Equilibrium:* Awareness of inconsistencies or contradictions
- *Confidence:* Degree of certainty in choices or statements

During our presentation we showed video clips that served as examples of each of these six aspects of students' reasoning about sampling distributions. Copies of the problems and interview protocol, as well as complete transcripts of the video clips were distributed to SRTL-2 participants. We gained valuable feedback on how to refine our methodology from the discussion and made new contacts that we hope will lead to collaborative research projects across institutions in the future.

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15. CONCEPTUAL ISSUES IN UNDERSTANDING SAMPLING DISTRIBUTIONS AND MARGIN OF ERROR

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This study presented at SRTL-2 employed two teaching experiments to probe essential difficulties in students' constructions of schemes and imagery that might underlie their ability to reason powerfully about distributions of sample statistics. The study's methodology involved analyzing the idea in terms of conceptual operations it might entail, designing objects and situations with the intent of bringing those operations into play within conversations around them, and employing those objects and situations within the teaching experiments. Analysis of the teaching experiment data entailed using the conceptual analysis to guide initial explanations of students' successes and difficulties and feedback into the conceptual analysis in those instances where it failed to provide satisfactory explanations of critical events.

The first teaching experiment comprised 9 instructional days with 27 junior and senior high school students followed by 60-minute interviews of 10 students. Instruction in the teaching experiment focused on having students build multi-level images of repetitively sampling from a population and tracking the sample statistics to form distributions generated there from, and determining invariant properties of those distributions. Videos from Teaching Experiment 1 revealed several, possible essential, difficulties students encountered. The first was their disposition to participate in lessons unproductively. The conversations that actually took place sometimes confused students who anticipated that the instructor would demonstrate procedures that they would then commit to memory. The conversations most often focused on how to understand important issues and on reasonable ways to conceive of them so that people might develop reasonable ways to approach problems entailing them (such as, what does it mean that a particular event is "unusual" and how to determine whether it is). The second difficulty, grounded more in conceptual operations, was some students' predilection to conceive of samples as "some of" a population, instead of as a proportional mini-version of the population. The third difficulty, also grounded in conceptual operations, was some students' inability to keep in mind processes occurring at multiple levels, and their concomitant difficulty conceiving products of those completed processes (e.g., thinking of the distribution of sample statistics where each statistic comes from a sample collected randomly from a population).

Teaching Experiment 2, conducted with 8 juniors and seniors over 20 lessons, with all 8 students interviewed twice during the experiment and once afterward, focused specifically on having students develop the orientations and operations that were found to be problematic in Teaching Experiment 1. The teaching experiment was successful in addressing the problems of students not being able to reason and track the results of multi-level processes. But one additional essential difficulty became evident that probably was at play in Teaching Experiment I but which was confounded with the other difficulties. It was students' predilection to think of outcomes non-stochastically. Thus, repeating a process many times might produce varying outcomes, but students tended to think of outcomes per se as being unassociated with some repeatable process that might produce them. Video segments from the teaching experiments served as points of departure for discussions during the presentation.

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CONCEPTIONS OF VARIATION: A LITERATURE REVIEW(1)

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SUMMARY

There are two parts to this literature review. The first part includes bibliography directly focusing on variation: meaning of variation, role of variation in statistical reasoning, research on conceptions of variation, as well as literature discussing the neglect of variation. The second part lists references belonging to four bodies of literature which, although not having the study of intuitions about variation as their main object of study, do offer rich insights into people's thinking about variation: literature on sampling and centers, on intuitions about the stochastic, on the role of technology, and on the effect of the formalist mathematics tradition on statistics education.

Keywords: *statistics education, variation, bibliography*

1. BIBLIOGRAPHY ON VARIATION

Pupils in the future will bring away from their schooling a structure of thought that whispers 'variation' matters (Moore, 1992, p.426).

1.1. MEANING OF VARIATION

The first consideration for someone interested in the study of intuitions about variation is the concept of variation itself. The following article by Wild and Pfannkuch identifies the issues necessary for the understanding of variation in data:

1. Wild, C. J. & Pfannkuch, M. (1999). Statistical thinking in empirical enquiry. *International Statistical Review*, *67*(3), 223-265.

1.2. IMPORTANCE OF VARIATION

The papers listed below emphasize the central role that variation plays in statistical reasoning and that consequently it should also play in statistics instruction and research of students' understanding of statistics:

2. Azcárate, P. & Cardeñoso, J. M. (1994). Why ask why? *Research papers from the Fourth International Conference on Teaching Statistics.* Minneapolis: The International Study Group for Research on Learning Probability and Statistics.
3. Ballman, K. (1997). Greater emphasis on variation in an introductory statistics course. *Journal of Statistics Education, 5*(2).
4. Biehler, R. (1999). Discussion: Learning to think statistically and to cope with variation. *International Statistical Review, 67*(3), 259-262.
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1.3. RESEARCH ON ROLE OF VARIATION IN STATISTICAL REASONING

Very few studies exist in the research literature, which focus directly upon students' conceptions of variation. I have located the following:

14. Meletiou, M. (2000). *Developing students' conceptions of variation: an untapped well in statistical reasoning*. Ph.D. Thesis, University of Texas at Austin.
15. Nicholson, J. (1999). Understanding the role of variation in correlation and regression. Presented at the *First International Research Forum on Statistical Reasoning, Thinking and Literacy*, Be'eri, Israel.
16. Reading, C. (1999). Variation in sampling. Presented at the *First International Research Forum on Statistical Reasoning, Thinking and Literacy,* Be'heri, Israel.
17. Reading C. (2001). *Variation from a student´s perspective*. Presented at the *Second International Research Forum on Statistical Reasoning, Thinking, and Literacy*, Armidale, Australia.
18. Reading, C. & Shaughnessy, J. M. (2000). Student perceptions of variation in a sampling situation. In T. Nakahar & M. Koyama. (Eds.), *Proceedings of the 24th Conference of the International Group for the Psychology of Mathematics Education* (Vol. 4, pp. 89-96) Hiroshima, Japan.
19. Robinson, G. (2000). *Selling a course on experimentation*. Presented at the *OZCOTS-3 Statistical Education Workshop*, Swinburne University of Technology, Australia.
20. Shaughnessy, J. M. (2001). *Conflict between students´ personal theories and actual data: The spectre of variation*. Presented at the *Second International Research Forum on Statistical Reasoning, Thinking, and Liter*acy, Armidale, Australia.
21. Shaughnessy, J. M. (2002). Aspects of students´ understandings of variation. To be published in: *Proceedings of the Sixth International Conference on Teaching Statistics.* Cape Town, South Africa.
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23. Watson, J. (2002). Can grade 3 students learn about variation? To be published in: *Proceedings of the Sixth International Conference on Teaching Statistics.* Cape Town, South Africa.

The following articles, which I have submitted for publication and are available upon request, discuss the findings of a study conducted in a college level introductory statistics course that adopted a non-conventional approach to statistics instruction with variation as its central tenet:

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1.5. NEGLECT OF VARIATION

The references that follow acknowledge the almost complete absence of research on variation and provide possible explanations for the tendency of textbooks, instruction, and research to look at centers in data while ignoring variability: In addition to [1], [22]:

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2.2. LITERATURE ON INTUITIONS ABOUT THE STOCHASTIC

Heuristics Literature

The very large and influential body of research that examines the informal strategies or heuristics people use when making judgments under uncertainty and which has come to be known as the heuristics literature, is also extremely useful in giving insights regarding students' intuitions about variation. References such as the following point to people's deterministic mindset and their limited ability to cope with uncertainty and variation. In addition to [41], [43]:

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49. DelMas, R. C., Garfield, J. & Chance, B. L. (1999). A model of classroom research in action: Developing simulation activities to improve students' statistical reasoning. Journal of Statistics Education, 7*(3).* [On-line]. Available: http://www.amstat.org/publications/jse/secure/v7n3/delmas.cfm
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53. Konold, C. (1989). Informal conceptions of probability. *Cognition and Instruction, 6,* 59-98.
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55. Shaughnessy, J. M. (1977). Misconceptions of probability: An experiment with a small-group, activity-based, model building approach to introductory probability at the college level. *Educational Studies in Mathematics, 8,* 285-316.
56. Tversky, A. & Gilovich, T. (1989). The cold facts about the "hot hand" in basketball. *Chance, 2(1),* 16-21.
57. Tversky, A. & Kahneman, D. (1973). Availability: A heuristic for judging frequency and probability. *Cognitive Psychology, 5,* 207-232.

58. Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and biases. *Science*, *185,* 1124-1131.
59. Tversky, A. & Kahneman, D. (1983). Extensional versus intuitive reasoning: The conjunction fallacy in probability judgement. *Psychological Review, 90*(4), 293-313.

Criticisms of the Heuristics Literature – Intuitions as Dynamic

A growing number of researchers have lately become critical of the heuristics literature because of its emphasis on discovering fallibilities in peoples' reasoning. The work of these researchers who, although acknowledging that our intuitions often run counter to stochastic reasoning, view those intuitions as dynamic and subject to development, can also be very valuable to the researcher and educator interested in building student conceptions of variation. In addition to [31], [41]:

60. Borovcnik, M. (1991). A complementarity between intuitions and mathematics. In D. Vere-Jones (Ed.), *Proceedings of the Third International Conference on Teaching Statistics* (*Vol.1,* pp. 363-369). Voorburg, The Netherlands: International Statistical Institute.
61. Borovnik, M. & Peard, R. (1996). Probability. In A. J. Bishop (Ed.), *International Handbook of Mathematics Education* (pp. 239-287).Dordrecht, the Netherlands: Kluwer.
62. Confrey, J. (1991). Learning to listen: A student's understanding of powers of ten. In E. von Glaserfeld (Ed.), *Radical constructivism in mathematics education* (pp. 111-136). Dordrecht, the Netherlands: Kluwer.
63. Fischbein, E. (1975). *The intuitive sources of probabilistic thinking in children*. Dordrecht, the Netherlands: Reidel.
64. Fischbein, E. (1987). *Intuition in science and mathematics.* Dordrecht, the Netherlands: Reidel.
65. Gigerenzer, G. (1996). On narrow norms and vague heuristics: A rebuttal to Kahneman and Tversky. *Psychological Review, 103* (3).
66. Jacobs, J. E. & Potenza, M. (1991). The use of judgement heuristics to make social and object decisions: a developmental perspective. *Child Development, 62,* 166-178.
67. Jones, G., Thornton, C., Langrall, C. & Mogill, A. T. (1997). Using students' probabilistic thinking to inform instruction. In J. Garfield & J. Truran (Eds.), *Research papers on Stochastics Education* (pp. 171-178).
68. Konold, C. (1995). Issues in assessing conceptual understanding in probability and statistics. *Journal of Statistics Education*, *3*(1).
69. Pratt, D. C. (1998). *The construction of meanings in and for a stochastic domain of abstraction.* Ph.D. Thesis, University of London.
70. Shaughnessy, J. M. (1997). Discussion: Empirical research on technology and teaching statistics. In J. Garfield & J. Truran (Eds.), *Research papers on stochastics education* (pp. 217-219).
71. Smith, J. P., diSessa, A.A. & Rochelle, J. (1993). Misconceptions reconceived - a constructivist analysis of knowledge in transition. *Journal of Learning Sciences, 3*(2), 115-163.
72. Wilensky, U. (1993). *Connected mathematics - building concrete relationships with mathematical knowledge*. Ph.D. Thesis, Massachusetts Institute of Technology.
73. Wilensky, U. (1997). What is normal anyway? Therapy for epistemological anxiety. In R. Noss (Ed.), *Educational Studies in Mathematics. Special Issue on Computational Environments in Mathematics, 33*(2), 171-202.

2.3. THE ROLE OF TECHNOLOGY

The computer's ability to repeat experiments through simulations, provides a potential advantage that could be exploited to help develop students' skills in recognizing uncertainty and variation and distinguishing among the different types of variation. The extensive literature which describes how technology is employed or could be employed in the statistics classroom to support the development of didactic materials related to variation ideas such as randomness, sampling distribution, and central limit theorem, provides information about the role of computers and other technological tools in shaping student conceptions of variation. Examples include, in addition to [6], [[15], [43], [69]:

74. Behrens, J. T. (1997). Toward a theory and practice of using interactive graphics in statistical education. In J.

B. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 111-121). Voorburg, the Netherlands: International Statistical Institute.

75. Ben-Zvi, D. & Friedlander, A. (1997). Statistical thinking in a technological environment. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 54-64). Voorburg, the Netherlands: International Statistical Institute.
76. Blumberg, C. J. (1997). Discussion: How technology is changing the teaching of statistics at the college level. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 279-283). Voorburg, the Netherlands: International Statistical Institute.
77. Burrill, G. (1997). Graphing calculators and statistical reasoning at the secondary level through the use of technology. In J. B. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 15-28). Voorburg, the Netherlands: International Statistical Institute.
78. Burrill, G. (1997). Discussion: Technology, reaching teachers, and content. In J. B. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 71-74). Voorburg, the Netherlands: International Statistical Institute.
79. delMas, R. C. (1997). A framework for the evaluation of software for teaching statistical concepts. In J. B. Garfield & G. Burrill (Eds.), *Research on the Role of Technology in Teaching and Learning Statistics* (pp. 75-90). Voorburg, the Netherlands: International Statistical Institute.
80. Garfield, J. (1997). Preface. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. ix-xi). Voorburg, the Netherlands: International Statistical Institute.
81. Garfield, J., delMas, B. & Chance, B. L. (1999). *Tools for teaching and assessing statistical inference: simulation software* [On-line]: htpp://www.gen.umn.edu/faculty_staff/delmas/stat_tools/stat_tools_softare.htm
82. Glencross, M. J. & Binyavanga, K. W. (1997). The role of technology in statistics education: A view from a developing region. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 301-308). Voorburg, the Netherlands: International Statistical Institute.
83. Ghosh, J. K. (1997). Discussion. *International Statistical Review, 65*(2), 154-155.
84. Hawkins, A. (1997). Myth-conceptions. In J. B. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. vii-viii). Voorburg, the Netherlands: International Statistical Institute.
85. Konold, C. (1995). Confessions of a coin flipper and would-be instructor. *The American Statistician*, *49*(2), 203-209.
86. Lipson, K. (1997). What do students gain from simulation exercises? An evaluation of activities designed to develop an understanding of the sampling distribution of a proportion. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 137-150). Voorburg, the Netherlands: International Statistical Institute.
87. Meletiou, M. & Lee, C. (2000). Technology Impact on undergraduate statistics instruction. *Proceedings of the 2nd Mediterranean Conference on Mathematics Education*. Nicosia, Cyprus.
88. Meletiou, M., Lee, C. & Fouladi, R. (2002). The role of technology on student understanding of inferential statistics. Submitted for publication in: *Journal of Computers in Mathematics and Science Teaching.*
89. Meletiou, M., Lee, C. M. & Myers, M. (1999). The role of technology in the introductory statistics classroom: reality and potential. *Proceedings of the International Conference on Mathematics/Science Education and Technology* (pp. 292-297). San Antonio, Texas.
90. Meletiou, M. & Martin, W. (2001). Collaborative learning and the use of technology: experiences gained from a statistics course. Abstract published in: *Abstracts of papers presented to the Joint AMS-MAA meeting*. Louisiana, New Orleans. [On-line]. Available: http://www.ams.org/amsmtgs/2025_abstracts/962-s1-1359.pdf.
91. McCloskey, M. (1997). QERCUS and STEPS: The experience of two CAL projects from Scottish universities. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 99-109). Voorburg, the Netherlands: International Statistical Institute.
92. Moore, D. (1997). New pedagogy and new content: the case of statistics. *International Statistical Review, 65*(2), 123-165.
93. Rossman, A. J. (1997). Using technology to promote learning by self-discovery. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 226-237). Voorburg, the

Netherlands: International Statistical Institute.

94. Scheaffer, R. L. (1997). Discussion. *International Statistical Review, 65*(2), 156-158.
95. Schuyten, G. & Dekeyser, H. (1997). Computer-based and computer-aided learning of applied statistics at the department of psychology and educational sciences. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 213-222). Voorburg, the Netherlands: International Statistical Institute.
96. Starkings, S. (1997). How technological introduction changes the teaching of statistics and probability at the college level. In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 233-254). Voorburg, the Netherlands: International Statistical Institute.
97. Wilder, P. (1994). Students' understanding of computer-based simulations of random behavior. *Research papers from the Fourth International Conference on Teaching Statistics.* Minneapolis: The International Study Group for Research on Learning Probability and Statistics.
98. Wilder, C. (1994). Embracing the "wider view" of statistics. *The American Statistician, 48*, 163-17.
99. Wood, M. (1997). Computer packages as a substitute for statistical training? In J. Garfield & G. Burrill (Eds.), *Research on the role of technology in teaching and learning statistics* (pp. 267-278). Voorburg, the Netherlands: International Statistical Institute.

2.4. BELIEFS ABOUT THE NATURE OF MATHEMATICS: IMPACT ON STATISTICS

The references below discuss how the formalist mathematics culture with its over-emphasis on determinism and its "orientation towards exact numbers" (Biehler, 1997, p. 187) affects statistics education. They help explain why, in contrast to the varied and extremely rich models of central tendency found in the literature, sterile approaches to the notion of variability (Shaughnessy, 1997) dominate both the curriculum and the research literature. In addition to [28], [29], [31], [72], [83], [93]:

100. Vallecillos, A. & Holmes, P. (1994). Students' understanding of the logic of hypothesis testing. In J. B. Garfield (Ed.), *Research papers from the Fourth International Conference on Teaching Statistics.* Minneapolis: The International Study Group for Research on Learning Probability and Statistics.
101. Metz, K. E. (1997). Dimensions in the assessment of students' understanding and application of chance. In I. Gal & J. B. Garfield (Eds.), *The assessment challenge in statistics education* (pp. 223- 238). Amsterdam: IOS Press.
102. Steinbring, H. (1990). The use of chance-concept in everyday teaching - aspects of a socially constituted epistemology of mathematical knowledge. In J. B. Garfield (Ed.), *Research papers from the Third International Conference on Teaching Statistics.* University of Otago, Dunedin, New Zealand.

3. CONCLUDING REMARKS

The bibliography I have presented here is not by any means comprehensive. Since I have a special interest in research on variation, I would appreciate the sharing of references by other researchers and statistics educators.

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RECENT PUBLICATIONS

Ainley, J., Nardi, E. & Pratt, D. (2000) Towards the construction of meanings for trend in active graphing. *The International Journal of Computers for Mathematical Learning*, 5(2), 85-114.

The development of increased and accessible computing power has been a major agent in the current emphasis placed upon the presentation of data in graphical form as a means of informing or persuading. However research in Science and Mathematics Education has shown that skills in the interpretation and production of graphs are relatively difficult for Secondary school pupils. In this paper we explore the conjecture that the use of computers in education has the potential to revolutionise the ways in which children learn graphing skills. We describe research with 8 and 9 year olds using on a pedagogic strategy which we call Active Graphing, in which spreadsheets are use to collect and present data from practical experiments, and present results which indicate that children gain higher levels of interpretative skills, particularly in terms of the use of trend, through this approach than would be expected in traditional classrooms.

Batanero, C., Tauber, L. & Sánchez, M. V. (In press). *Significado y comprensión de la distribución normal en un curso introductorio de análisis de datos* (Meaning and understanding of normal distributions in an introductiory course of data análisis). Quadrante.

In this paper we describe an experience for teaching the normal distribution inside a course of data analysis based on the use of computers, and directed to students in their first year of University studies. Basing on a theoretical framework about the meaning of mathematical objects, we describe different elements of meaning in the normal distribution and emphasize the specific elements induced by the use of computers. We assess the knowledge acquired by our students, at the end of the course by using two different instruments: a) A written questionnaire; b) Three tasks regarding a new data file to be solved with the help of computers. A detailed analysis of students' responses show that the students learnt to use the software and acquired many elements of meanings considered in the teaching. On the contrary, we observed difficulties in discriminating empirical data and mathematical models, interpreting some statistics summaries and graphs and lack of analysis and synthesis ability.

Doane, D. & Tracy, R. (2000). Using beam and fulcrum displays to explore data. *The American Statistician,* 54(4), 289-290.

The beam-and-fulcrum display is a useful complement to the box plot. It displays the range, mean, standard deviation, and studentized range. It reveals the existence of outliers and permits some assessment of shape. Embellishments to the beam-and-fulcrum diagram can show the item frequency, and/or a confidence interval for the mean. Its intuitive simplicity makes the beam-and-fulcrum an attractive tool for exploratory data analysis (EDA) and classroom instruction.

Frykholm, J. (2001). Eenie, Meenie, Minie, Moe . . . building on intuitive notions of chance, *Teaching Children Mathematics*, 8(2), 112.

A childhood selection game initiates an investigation of how children view fairness and chance. The examples shared in this article represent possible starting points for developing probability understanding in young children.

Gourgey, A. (2000). A classroom simulation based on political polling to help students understand sampling distribution, *Journal of Statistics Education*, 8(3).

Sampling distributions are central to understanding statistical inference, yet they are one of the most difficult concepts for introductory statistics students. Although hands-on teaching methods are preferred, finding the right balance between theory and practical experience has not been easy. Simulation activities have not always captured the research situations that statisticians work with. This paper describes a method developed by the author to teach sampling distributions using a collaborative learning simulation based on political polling. Anecdotally, students found the polling scenario easy to understand, interesting, and enjoyable, and they were able to explain the meaning of sample results and inferences about the population. Sample examination questions are included, with examples of students' responses that suggest that the method helped them to understand sampling error and its role in statistical inference.

Lesser, L. M. (2001). Musical means: Using songs in teaching statistics. *Teaching Statistics*, 23 (3), 81-85.

Students' ready understanding of and interest in the context of songs and music can be utilised to motivate all grade levels to learn probability and statistics. Content areas include generating descriptive statistics, conducting hypothesis tests, analysing song lyrics for specific terms as well as "big picture" themes, exploring music as a data analysis tool, and exploring probability as a compositional tool. Musical examples span several genres, time periods, countries and cultures

Moscoloni, N. (2000) About figures and data in social research and social action, *Anuario del Departamento de Ciencias de la Comunicación,* Volumen 5, Escuela de Comunicación Social, Facultad de Ciencia Política y Relaciones Internacionales, Universidad Nacional de Rosario, ArcaSur Editorial, Rosario.

In order to rescue the value of quantitative tools faced to the present paradigm in the Social Sciences, a different kind of seminary titled Quantitative Data Analysis was submitted to the School of Social Communication of the Faculty of Politic Sciences of the National University of Rosario. Actually the cancellation of Statistics out of the curricula was mainly due to the influence of epistemological points of view against functionalism, positivism or simplifier methods that neglect the complexity of social events. This paper deals with the main ideas underlying this pedagogic proposal that implies to explicit some topics as the ones listed next. The distinction between the use and the abuse of statistics especially in the media should be pointed out. The difference existing between the tool itself and the intention of the person that manipulates the tool needs to be stated. The efforts made by the international statistical community in order to improve the teaching of statistics not only at school but also to the public. The importance for the social research methodology to give to data construction, in opposition to simply manipulate figures should be demonstrated. The influence of multidimensional data analysis approach on social research today is proved to be increasingly important.

Martinez-Dawson, R. (2001) An interdisciplinary approach to teaching statistics: Incorporating laboratory experiments in an introductory statistics course, *2001 Joint Statistical Meeting Proceedings of the Section on Statistical Education*.

To create an interdisciplinary focus and a more reality-based experience, laboratory experiments using spectrophotometers, scales, and pH meters were incorporated in an undergraduate introductory statistics course. Students enrolled in this course are comprised of non-statistics majors such as engineering, agriculture, health-related fields etc. By using lab equipment commonly associated with science laboratory experiments, students will be exposed to the interrelationship of science and statistics through experimental design and data analysis. The laboratory experiments used in the course will be discussed. These experiments are related to fields such as chemistry, biology, and environmental sciences. Student attitudes toward the laboratory experiments will be assessed. The effect of demographic attributes such as age, gender, major, classification on attitude toward the experiments will be presented.

Moritz, J. B. & Watson, J. M. (2000). Reasoning and expressing probability in students' judgements of coin tossing. In J. Bana & A. Chapman (Eds.), *Mathematics education beyond 2000. Proceedings of the 23rd Annual Conference of the Mathematics Education Research Group of Australasia* (pp. 448-455). Perth, WA: MERGA.

A survey item based on a newspaper article about coin tosses was administered to 1256 students from grades 6 to 11. Few students successfully determined the probability of four successive tails. Most students considered that heads and tails were equally likely for a subsequent fifth toss, often describing the probability as "50-50". Students in higher grades were more likely to respond appropriately. Results are discussed with reference to equiprobability, independence, the gambler's fallacy, and the outcome approach to probability.

Porter, A. (2001). Flexible deliver of statistics. *Bulletin of the International Statistical Institute*, 2, 457-458.

In this paper I discuss the move from being a classroom teacher of statistics to a teacher who is developing learning resources for on-line delivery to students. The change is from a classroom teacher where flexible delivery has meant drawing on the sights, sounds, movement, quiet and live shows to a teacher feeling the constraints of translating activity based programs to technologically based programs. In the talk I discuss possible ways enriching on-line resources, so that the learning experience is not second to that of the classroom.

Pratt, D. (2000). Making sense of the total of two dice. *Journal for Research in Mathematics Education*, 31(5), 602-625.

Many studies have shown that the strategies used in making judgements of chance are subject to systematic bias. This study examines an associated, but sparsely researched, area of paramount importance to education. Little is known about the relationship between the external structuring resources, made available for example in a pedagogic environment, and the construction of new internal resources, such as intuitions, about chance and randomness. This study uses a novel approach in which young children articulated their meanings for chance through their attempts to 'mend' possibly broken computer-based stochastic gadgets. Here I describe the interplay between informal intuitions and computer-based resources as the children construct new internal resources for making sense of the total of two spinners and two dice.

Pratt, D. & Noss, R. (In press): The micro-evolution of mathematical knowledge: The case of randomness, *Journal of the Learning Sciences*.

In this paper we explore the growth of mathematical knowledge and in particular, seek to clarify the relationship between abstraction and context. Our method is to gain a deeper appreciation of the process by which mathematical abstraction is achieved and the nature of abstraction itself, by connecting our analysis at the level of observation with a corresponding theoretical analysis at an appropriate grain size. In this paper we build on previous work to take a further step towards constructing a viable model of the microevolution of mathematical knowledge in context. The theoretical model elaborated here is grounded in data drawn from a study of 10-11 year olds' construction of meanings for randomness in the context of a carefully designed computational micro world, whose central feature was the visibility of its mechanisms--how the random behavior of objects actually "worked". In this paper, we illustrate the theory by reference to a single case study chosen to illuminate the new knowledge. Our explanation will employ the notion of situated abstraction as an explanatory device that attempts to synthesize existing micro- and macro-level descriptions of knowledge construction. One implication will be that the apparent dichotomy between as affording different perspectives on a broadening of contextual neighbourhood over which a network of knowledge elements applies.

Quinn, R. (2001). Using attribute blocks to develop a conceptual understanding of probability. *Mathematics Teaching in the Middle School*, 6(5), January, 290-294.

Activities using attribute blocks can help middle school students construct knowledge about, and develop conceptual understanding of, probability.

Schield, A. (2000). Statistical literacy: Difficulties in describing and comparing rates and percentages. *ASA 2000 Proceedings of the Section on Statistical Education*.

A basic goal of statistical literacy is to construct readily understandable ratio-based comparisons that follow directly from data, take into account multiple factors and can support arguments about causation. College students have considerable difficulty constructing such comparisons using rates and percentages. This paper asserts that the main cause of student difficulties is the combination of complexity, subtlety and ambiguity. Complexity is the dominant source of difficulty. Indications of complexity include the unique grammars associated with the three kinds of arithmetic comparisons and four families of named ratios: ratio, percentage, rate and chance. To add to the complexity there are two ways of using percent, three ways of using percentage and seven ways of using rate in descriptions. For each of the 10 ways of using percentage or rate descriptions, there is a corresponding comparison. And there are four ways of using likely in comparisons. Examples of subtlety and ambiguity are presented. Subtle differences in syntax (grammar) are shown to cause significant difference in semantics (meaning). The defining and comparing of rates and percentages is also difficult because it includes most of the mathematical difficulty of using English to describe the concepts of variable, function, multivariate function and partial derivative. Web copy: www.augsburg.edu/ppages/~schield

Schield, M. (2001) Statistical literacy: Reading tables of rates and percentages. *ASA 2001 Proceedings of the Section on Statistical Education*.

Statistical literacy depends on the ability to read and compare data presented in tables and graphs. Tables of rates and percentages are very useful in supporting arguments, but these tables are often difficult to decode. This paper presents rules for determining whether an index variable in such a table is part or whole depending on

whether the associated margin value is an average, a sum or a 100% sum. Tables with missing margin values ˆ date-indexed tables, half tables and control tables ˆ are analyzed. Recommendations are made to improve reader understanding of any table involving rates or percentages. Web copy: www.augsburg.edu/ppages/~schield

Torok, R. & Watson, J. (2000). Development of the concept of statistical variation: An exploratory study. *Mathematics Education Research Journal*, 12, 147-169.

An appreciation of variation is central to statistical thinking, but very little research has focused directly on students' understandings about variation. In this exploratory study, four students from each of grades 4, 6, 8, and 10 were interviewed individually on aspects of variation present in three settings. The first setting was an isolated random sampling situation, whereas the other two settings were realistic sampling situations. Four levels of responding were identified and described in relation to developing concepts of variation. Implications for teaching and future research on variation are considered.

Wang, A (2001) How much can be taught about stochastic processes and to whom? In C. Batanero (Ed.), *Training researchers in the use of statistics* (pp. 73-85). Granada: International Association for Statistical Education and International Statistical Institute.

Researchers quite often need to model and analyse real-world phenomena using stochastic processes. Learning stochastic processes requires a good knowledge of probability theory, calculus, matrix algebra and a general level of mathematical maturity. However, not all researchers have a good foundation in probability and mathematics. In this paper, we discuss different approaches to the teaching of a first course in stochastic processes to researchers. Difficulties in the understanding of a stochastic processes and the various mathematical techniques used in stochastic processes are discussed. Proposal for the core topics of such a course and ways of teaching them are put forward.

Wang, A. (2001). Introducing Markov chain models to undergraduates, *Bulletin of the International Statistical Institute 53rd Session*, (invited papers), Book 2, 179-182.

Learning Markov chains models requires some knowledge of probability theory, matrix algebra and a general level of mathematical maturity. While trying to understand Markov chains models, students usually encounter many obstacles and difficulties. In this paper, some suggestions regarding the teaching of introductory Markov chains models to undergraduates are discussed.

Watson, J. M. (2000). Preservice mathematics teachers' understanding of sampling: Intuition or mathematics. *Mathematics Teacher Education and Development*, 2, 121-135.

This paper considers 33 preservice secondary mathematics teachers' solutions to a famous sampling problem, well known for confounding educated adults: the "hospital problem" of Tversky and Kahneman. Of particular interest is the use of intuition and/or formal mathematics in reaching a conclusion. The relationships of solution strategy to students' background in formal mathematics and to gender are also considered. Implications for teaching statistics at both the secondary and preservice teacher education levels are discussed briefly.

Watson, J. M. & Moritz, J. B. (2000). Development of understanding of sampling for statistical literacy. *Journal of Mathematical Behavior*, 19, 109-136.

The development of understanding sampling is explored through responses to four items in a longitudinal survey administered to over 3000 students from grades 3 to 11. Responses are described with reference to a three-tiered framework for statistical literacy, including defining terminology, applying concepts in context, and questioning claims made without proper justification. Within each tier increasing complexity is observed as students respond with single, multiple, and integrated ideas to the four different tasks. Implications for mathematics educators of the development of sampling concepts across the years of schooling are discussed.

Watson, J. M. & Moritz, J. B. (2000). Developing concepts of sampling. *Journal for Research in Mathematics Education*, 31, 44-70.

In developing ideas associated with statistical inference, a key element involves developing concepts of sampling. The objective of this research is to understand the characteristics of students' constructions of the concept of sample. Sixty-two students in grades 3, 6, and 9 were interviewed using open-ended questions related to sampling; written responses to a questionnaire were also analyzed. Responses were characterized in relation to the content, structure and objectives of statistical literacy. Six categories of construction were identified and described in relation to the sophistication of developing concepts of sampling. These categories illustrate helpful and unhelpful foundations for an appropriate understanding of representativeness and hence will help curriculum developers and teachers plan interventions.

Wood, M. (2001). The case for crunchy methods in practical mathematics, *Philosophy of Mathematics Education Journal 14*, available at http://www.ex.ac.uk/~PErnest/pome14/wood.htm.

This paper focuses on the distinction between methods which are mathematically "clever", and those which are simply crude, typically repetitive and computer intensive, approaches for "crunching" out answers to problems. Examples of the latter include simulated probability distributions and resampling methods in statistics, and iterative methods for solving equations or optimisation problems. Most of these methods require software support, but this is easily provided by a PC. The paper argues that the crunchier methods often have substantial advantages from the perspectives of user-friendliness, reliability (in the sense that misuse is less likely), educational efficiency and realism. This means that they offer very considerable potential for simplifying the mathematical underlying many areas of applied mathematics such as management science and statistics: crunchier methods can provide the same, or greater, technical power, flexibility and insight, while requiring only a fraction of the mathematical conceptual background needed by their cleverer brethren.

RECENT DISSERTATIONS

Mark Earley (2001). *Investigating the development of knowledge structures in introductory statistics.* PhD. University of Toledo, OH. Supervisor: Dr. Thomas G. Dunn.

The main questions addressed by this study were: (a) what do the knowledge structures of introductory statistics students look like, (b) how do these knowledge structures change as the semester progresses, and (c) are there any similarities or differences among different students' structures? Nine graduate students enrolled in an introductory educational statistics course agreed to meet with me one-on-one once every three weeks during the term they were taking the course. Each session, we discussed course concepts and how the student believed they related to each other. Each session included previous concepts we had discussed plus new concepts taught in class since our last session. The final session included a discussion of 45 statistical concepts and their relationships.

The theoretical perspective I chose for this study was Anderson's ACT-R* theory. In particular, I am interested by the idea that students learn more than just *declarative knowledge*, or facts and definitions, and *mechanical knowledge*, or procedures and processes. Anderson and others (e.g., Jonassen, Beissner & Yacci; Byrnes) argue that there is a third type of knowledge students actively build as they learn: *structural or relational knowledge*. This third type of knowledge serves to relate all of the declarative and mechanical knowledge students learn. My thesis is that this third type of knowledge is an indication of a student's understanding of the material they are learning. If these structures are not integrated or complex, then neither is the student's understanding. The main idea here follows the current trends in statistics education research, that students need to know more than what the mean is or how to calculate it (declarative and mechanical knowledge respectively); they also need to know what the mean tells us about a set of data and why it is an important indicator of a sample's central tendency. They also need to understand, for example, why we cannot calculate a mean for nominal and ordinal variables such as gender or class rank.

The results of my dissertation did demonstrate students' ability to organize course concepts in a way that is meaningful to them. With nine different organizations, I also present evidence that even though students are taking the same course, with the same instructor and same textbook, they do build different understandings (constructivism is also an important theoretical perspective captured by this data). Finally, with five different organizations over an entire semester, I present evidence that students' organizations do change. Future research needs to explore these organizations in more depth to determine how students develop these organizations, what might lead them to change their organizations, and what these organizations mean as an indicator of students' statistical knowledge.

Li Jun (2000). *Chinese students' understanding of probability.* PhD. Nanyang Technological University. Supervisor: Lionel Pereira-Mendoza.

This study investigated the following three questions: What are the Chinese students main misconceptions of probability? What is the developmental structure of students' understanding of probability? Can an activity-based short-term teaching programme improve ordinary grade 8 students' understanding of probability? The first two questions were answered in the main study. The sample was 567 Chinese students from three grades (6, 8 and 12) and two school streams (ordinary and advanced). After one year, six activity-based lessons which focused on empirical probability were given to two grade 8 classes in an ordinary school. The approaches were parallel except that one class had the opportunity to see computer simulations of a long series of experiments, while the other class was given the data in written form. All the students were tested and interviewed both prior to and after the teaching intervention.

Fourteen groups of misconceptions were observed in this study. The outcome approach, chance cannot be measured mathematically, compound approach and equiprobability were the main misconceptions for each grade and each stream of students. The context and data used in an item were found to play a role in eliciting some misconceptions. Using the SOLO taxonomy, it was found that, generally, there was no improvement in developmental level at grades 6 and 8, the two grades without any formal probability training. Grade 12 students have a better understanding than the younger students. The results of the teaching show that a short intervention can help students overcome some of their misconceptions. Students in the two classes improved substantially in their answers and reasoning but no statistically significant difference was found between the classes.

Antonio Moreno (2001). *Investigación y enseñanza de la estadística inferencial en el nivel de secundaria* [Research and teaching on statistical inference at secondary school level]. Master's Thesis. University of Granada. Supervisor: Angustias Vallecillos.

Curricular documents for secondary school level in Spain have recently been paying more attention to statistics and probability to take into account the need for a general education of citizens, according to recommendations previously made in other countries. A main change is the introduction of statistical inference at this level.

The aim of this project was to complement previous research in the area of teaching inference and to analyse, from a theoretical point of view, the problems involved in the introduction of statistical inference in secondary school. Three complementary area have been examined: a) the Andalusian official curriculum for the teaching of statistical inference at secondary school level, b) previous research about teaching and learning of statistical inference at secondary school level, and, c) results from an exploratory study on the learning of statistical inference.

A main conclusion is that inferential reasoning involves the use of a model of sampling distributions which is not easy for secondary students to understand. Students do not use only a model to connect samples to populations, but they also rely on their previous conceptions, the type of problem, the sample size, and other factors. Introducing students to random phenomena allows them to correct their inappropriate representativeness heuristics and to best construct the sampling space. However, the students did not overcome their errors in identifying impossible and rare events, equiprobability bias, and overestimation of the sample mode.

Omar Rouan (2001*). Lecture et Interprétation des représentations graphiques des données statistiques chez les élèves et les enseignants du secondaire* [Secondary school students and teachers' reading and interpretation of statistical data graphical representations]. Thèse de doctorat d'état (Ph.D) Université de Rabat. Supervisée par le Professeur Driss Lamrabet

Notre problématique se situe dans le cadre de la lecture et l'interprétation des représentations graphiques des données statistiques (RGDS), enseignées au niveau secondaire. Pour mieux la fonder, nous avons procédé à l'étude de l'évolution des programmes de statistique du niveau collégial et secondaire, à l'analyse descriptive des orientations pédagogiques associées à ces programmes et à celle des manuels scolaires correspondants. Comme nous avons procédé à l'analyse des résultats d'un questionnaire que nous avons adressé, dans ce but, à des enseignants de mathématiques du secondaire.

Notre revue de littérature a permis de préciser le sens de la terminologie utilisée, d'élaborer un modèle de compréhension des RGDS, utile pour l'analyser de nos graphiques et de dégager les différentes fonctions des RGDS à partir d'une étude de l'évolution historique de ce type de graphiques. Ces éléments ensemble, ont mené aux deux objectifs suivants:

1. Identifier le statut que les enseignants du secondaire associent aux RGDS, et les réactions qu'ils manifestent à l'égard de leur interprétation.
2. Identifier les difficultés de lecture et d'interprétation des RGDS, chez les élèves du secondaire, ainsi que les aspects de compréhension auxquels ces difficultés sont associées

Pour atteindre le premier objectif, nous avons adressé un questionnaire à 221 enseignants de mathématiques du secondaire. Nous avons aussi eu des entretiens avec certains entre eux. Pour atteindre le deuxième objectif, nous avons élaboré un questionnaire ayant quatre versions, deux pour l'histogramme , une pour le diagramme en bâtons et une pour le diagramme circulaire. Chacune de ces versions a été administrée à un nombre d'élèves, variant entre 130 et 150, de la première sciences expérimentales.

Les résultats concernant les enseignants, ont mis en évidences différentes conceptions erronées concernant l'objet de la statistique, les fonctions des RGDS, la définition de leur lecture et de leur interprétation. Pour les deux premières unités, les conceptions dominantes ont un aspect, soit descriptif, soit formel et calculatoire. Alors que pour les deux dernières, nous avons souvent constaté une confusion entre la lecture et l'interprétation des RGDS.

Les résultats concernant les élèves ont mis en évidences différents modes de lecture et d'interprétation des RGDS. Parmi ces derniers ''le mode discret'', ''le mode ordinal'', ''le mode fonctionnel'', ''le mode direct'' et le ''mode fonctionnel''. Ces modes de lecture et d'interprétation des RGDS, engendrent des difficultés associées aux différents aspects de compréhension de ces dernières. Les aspects concernés sont l'aspect structurel, l'aspect sémiotique, l'aspect descriptif et l'aspect fonctionnel. Les autres difficultés sont liées au rôles de destructeur visuel, que peut jouer le graphique.

Nous avons aussi pu constater que chacune des RGDS traitées est caractérisée par un type particulier de difficultés ou par la dominance d'un aspect particulier de compréhension. Ainsi pour l'histogramme et le diagramme en bâtons, ce sont surtout les difficultés engendrées par le mode "ordinal", liées aux aspects structurel et descriptif, qui dominent. Alors que le diagramme circulaire est caractérisé surtout par les difficultés engendrées par son rôle destructeur, dû à la domination de ses aspects iconique et spatial et à leur interférence avec les constituants du contexte de la situation.

Liliana Tauber (2001). *La construcción del significado de la distribución normal a partir de actividades de análisis de datos* [Building the meaning of normal distributions from data analysis activities]. PhD. University of Sevilla. Supervisors: Carmen Batanero and Victoria Sánchez.

In this research we are interested in the teaching and learning of normal distributions in an introductory data analysis course. The research is based on a theoretical framework where two different dimensions (institutional and personal) of meaning and understanding are considered for mathematical objects. We are interested in the following questions:

1. What is the institutional reference meaning of the normal distribution in a traditional introductory course of data analysis? In Chapter 4 we describe an empirical analysis of 11 University textbooks, from which we determine the main elements of meaning (problems, practices to solve these problems, representations, concepts, properties and types of arguments) that are presented in these textbooks in relation to the normal distribution.
2. How should the teaching of normal distribution be organised to take into account the use of computers? A teaching sequence of the normal distribution, which takes into account the result of the previous analysis and which incorporates the use of computers is described in Chapter 5. The main differences introduced by the use of computers as regards the reference meaning and the student's predicted activities in the different tasks are analysed.
3. What difficulties arise when developing this teaching? In fact, how is the teaching carried out? The observation of the teaching sequence in two successive academic years (1998-99) (1999-2000) and the interactions between the lecturer and the students in the different sessions are analysed in Chapter 6. The main points of difficulty and change predicted in the teaching are described.
4. How does the teaching work for students? What are their difficulties? What do they learn? (evolution of personal meaning along instruction). A total of 117 students were sampled. In each session the students, working in pairs, produced written documents with their solution to open-ended tasks. These documents were analysed to identify correct and incorrect elements of meaning that students used in their solutions. The progression in learning was clear as regards the theoretical concepts and use of software, and less general as regards the methods of solution or real data analysis activities.
5. What is the students' personal knowledge after teaching?. We used two different instruments to assess students' learning: a) a questionnaire; b) a data analysis activity from a new data file to be solved with the use of computers. The data analysis showed that the majority of students were able to understand isolated concepts associated with the normal distribution (on average each student gave 70% of correct answers in the questionnaire). On the contrary there was a great difficulty in integrating these elements to solve real data analysis problems (only 40% of students succeeded in the open task).

We conclude that data analysis is a high level activity which is difficult to teach in the time available for an introductory course, and that the main aim in these courses should be to train "users of statistics". Finally to complement our work, we compare the main differences in learning between students with and without previous statistical knowledge.

INFORMATION ON PAST CONFERENCES

1. STOCHASTICS PAPERS AT MERGA CONFERENCE, SYDNEY, JULY 2001

Reported by John M.Truran

The citation for the Proceedings is: J. Bobis, B. Perry & M. Mitchelmore (2001). Numeracy and Beyond. *Proceedings of the Twenty-fourth Annual Conference of the Mathematics Education Research Group of Australasia Incorporated,* University of Sydney, 30 Jun-4 July, 2001 No place of publication: Mathematics Education Research Group of Australasia Incorporated.

Burgess, T. Assessing the statistics knowledge of preservice teachers (Vol. 1, pp. 114-121).

This paper reports on aspects of preservice teachers' statistical knowledge as assessed through an open-ended problem-solving task. This type of task is considered to be a useful and valuable way of assessing the development of data sense. The level of a teacher's knowledge is known to be critical in relation to effective teaching. This study indicates that the level of statistics thinking of preservice students presents some challenges for teacher educators to address within their courses and programmes.

Chick, H. & Hunt, D. Pre-service primary teachers judgements about the probability of everyday events (Vol. 1, pp. 147-154).

A group of pre-service primary teacher students were asked to evaluate the probability of some everyday events, by (i) ranking the events in order of likelihood, (ii) assigning each event a probability word, and (iii) giving each event a numerical probability. Mismatches between ranking and numerical values were found, some students had difficulty estimating values for events with probabilities close to certain or impossible, and the ambiguity of some probability words was revealed. Students indicated that they thought that making such evaluations was associated with numeracy understanding, but not to the same extent as a more traditional computational number question.

English, L. Students' statistical reasoning in constructing newspaper articles (Vol. 1, pp. 194-201).

This paper addresses the final year of a 3-year longitudinal international study, which addressed the development of 9th and 10th grade students' statistical knowledge and reasoning processes. The study engaged students in the construction of data-based projects, which involved the processes of designing, analysing, interpreting, representing, communicating, and thinking critically and reflectively. This paper addresses students' reasoning on one of the final activities of the programme, namely, students' construction of newspaper articles. The findings highlight the importance of placing special emphasis on students' abilities to think about data and beyond data.

Nisbet, S. Representing categorical and numerical data (Vol. 2, pp. 378-385).

Teacher-education students were given the task of drawing two graphs, one to represent categorical data, the other to represent numerical data. A statistical-thinking framework was used to evaluate the graphs, produced by assigning levels of thinking to the graphs and comparing the levels associated with the two types of data. The levels of thinking associated with the categorical data were higher than those associated with the numerical data. More students were able to organise the categorical data compared to the numerical data. The levels of thinking were not related to the presentation of the data.

Watson, J. & Moritz, J. The role of cognitive conflict in developing students' understanding of chance measurement (Vol. 2, pp. 523-530).

In individual interviews, twenty students in each of grades 3, 6, and 9 responded to a task involving chance measurement, then viewed video recordings of other students' conflicting responses, and decided which response they preferred. Seven students improved their levels of reasoning, and seven agreed with the higher level prompts without expressing reasoning. Only two students agreed at some point with lower level prompts, and both reverted to the level of their original response in conclusion. Educational implications are noted.

2. THE 25TH PME CONFERENCE, 12 - 17 JULY, 2001, UTRECHT, THE NETHERLANDS

Reported by Chris Reading, creading@metz.une.edu.au

The following are abstracts of papers and presentations at PME25 and appear in: Van den Heuvel-Panhuizen, 2001, *Proceedings of the 25th Conference of the International Group for the Psychology of Mathematics Education*, Freudenthal Institute, The Netherlands.

1. Refereed Research Reports (printed in full in the proceedings)

Ayres, P. & Way, J. The effects of instruction on likelihood misconceptions. (Vol. 2, pp. 73-80).

This paper reports an investigation into the effects of instruction in probability concepts on the decision-making strategies of twenty-four 11-12 year olds. The instruction, based on small-group practical activities, had an overall positive influence on performance in specific probability tasks. It was also found that the particular experiences within the small groups of students had a strong influence on decision-making strategies in the final 'test' tasks. Groups that experienced sets of random outcomes in their activities that were not representative of the structure of the sample space tended to use inappropriate reasoning in later tasks.

Bakker, A. Symbolizing data into a 'bump'. (Vol. 2, pp. 81-88).

In this paper we analyze how concepts and symbolizations co-develop in the case of statistical data analysis. The focus is on the development of distribution, which ranges from a very concrete intuitive understanding to formal mathematical definitions. Examples from teaching experiments with 11 to 12 year-old students illustrate how their concept of distribution develops in relation to what the graphs they use and make mean for them. In particular we discuss an episode in which a student symbolizes data into a so-called 'bump' and we give examples of how other students reason with this 'bump' in connection to distribution.

Baturo, A. R. Conflict between perception, cognition and validation as year 12 and university students analyse the probability of an event. (Vol. 2, pp. 113-120).

Eighteen Year 12 students and 2 cohorts of final-year BEd students (74 students) were shown a "fair" (equiprobable outcomes) spinner with three non contiguous colours and asked whether each of the three colours had the same chance of "being spun". Half of the Year 12 students either gave unequivocal incorrect responses derived from inappropriate considerations of sector size or number of sectors per colour, or vacillated between correct and incorrect responses and were unable to make a decision (equivocal). These findings were echoed with the university students although their incorrect responses tended to be more unequivocal than equivocal. Validation through trialing (with the university students) did not help as the results did not show exactly 1 /3 for each colour and, in fact, were interpreted as supporting an incorrect response.

Carvalho, C. & César, M. Peer interactions and statistics learning (Vol. 2, pp. 217-224).

This research is part of the project Interaction and Knowledge, whose main aim is to study and promote peer interactions as one of the possible forms of developing pupils' socialisation and positive attitudes towards mathematics, as well as to promote their socio-cognitive development and enhance their school achievement. In this paper we analyse a case that illustrates the role of peer interactions in knowledge appropriation in a statistical task.

Doerr, H., M. & English, D. L. A modelling perspective on students' learning through data analysis. (Vol. 2, pp. 361-368).

A modelling approach to problem solving shifts the focus of the learning activity from finding an answer to a particular question to creating a system of relationships that is generalizable and re-usable. In this research paper, we discuss the nature of tasks that can be used to elicit the development of such systems. We present the findings from one classroom-based case study of Australian children and a summary of findings from all U.S. and Australian classes in our studies. Student reasoning about the relationships between and among quantities and their application in related situations is discussed. The case study suggests that students were able to create generalizable and re-usable systems (or models) for selecting and ranking data.

Gattuso, L. & Mary, C. Pupils' perception of the links between data and their arithmetic average. (Vol. 3 pp. 25-32).

The results presented in this paper are part of a larger study on the strategies used by pupils to solve arithmetic average problems. The arithmetic average being a widely used concept, it is important to study pupils' knowledge and their difficulties in order to improve their learning. Two questions arose from previous studies: 1) up to what point do pupils perceive the links between data and their average? And 2) does the introduction of a null datum(=0) complicate the situation? A first task asked for an estimation of the effect of the modification of a datum on the average and a second required finding the datum which would leave the average unchanged. The results tend to demonstrate that pupils have a fairly good perception of the effect of data modifications on the average with better results if the datum is zero.

Murtonen, M. & Merenluoto, K. Novices' and experts' knowledge on statistics and research methodology. (Vol. 3, pp. 391-398).

Many social science students in university constantly experience difficulties with research methodology and statistics courses. In this study we compared novice students', advanced students' and experts' knowledge on these complex and difficult domains. The results of the study refer to a tendency for novices, especially when they have had problems with mathematical subjects, to place the contents to emotional or other irrelevant categories which restricts or blocks their other cognitive activities on these subjects. There was a remarkable difference in the fragmentation of concept maps and explanations between novices, advanced students and experts. The novices were also not able to use sufficient representations to understand the concepts.

Reading, C. Understanding data collection. (Vol. 4, pp. 89-96).

Recent changes in the research agenda, fuelled by curricula changes, have focused on considering what 'statistical thinking' really means. To assist educators in both curriculum design and assessment more needs to be known about students' statistical understanding. This paper takes up the theme by considering students' responses to two open-ended tasks, based on scenarios involving data collection. The first task requires a suitable data collection method to be suggested, while the second task suggests the method but asks for implementation details. In both, a justification for the answer is elicited. A developmental sequence of nine levels was identified and the responses to the two data collection questions were analysed. The SOLO Taxonomy was used as the theoretical framework to assist this process.

Truran, J. A framework for assessing questions investigating the understanding of probabilistic concepts. (Vol. 4, pp. 287-294).

Research has suggested that two well-regarded tests of probabilistic understanding measure different constructs. Here a framework is proposed for classifying questions on probabilistic understanding and used to analyse the structure of the tests. It provides a way of predicting some differences found by post factum statistical analysis. This suggests that it may have more general validity for evaluating instruments assessing probabilistic understanding.

Watson, J. M. & Chick, H. L. A matter of perspective: Views of collaborative work in data handling. (Vol.4, pp. 407-414).

This paper reports on a study of students' collaborative group work in a grade 5/6 classroom using an open-ended task from the chance and data part of the mathematics curriculum. It considers (a) students' beliefs about collaborative group work compared to their actions; (b) observations of student knowledge, learning, and outcomes during collaboration compared to understanding displayed in individual interviews after work was completed; (c) students' accounts of events that took place in their groups compared with what was recorded on videotape; and (d) students' perceptions of the task and their beliefs about the mathematics curriculum.

2. Short Oral Presentations

Cortina, J. L. Three ways of using the arithmetic mean. (Vol.1, p. 299).

Three different uses of the mean have been identified; as a measure of the aggregate, as a measure of center and as an inferential tool. Each use is described and also included is a suggestion as to when each is best introduced into the curriculum.

Huerta, P. Probability problem solving in training mathematics teachers. The cave problem. (Vol.1, p. 318).

The CAVE Problem is used for a problem solving activity when teaching and learning probability and statistics in training primary and secondary teachers. In solving the problem three stratum have been identified which are associated with different school levels, primary, secondary and college.

Moreno, A. & Vallecillos, A. Exploratory study on inferential concepts learning in secondary level in Spain.(Vol.1, p. 343)

A summary communication of first results obtained in an exploratory study on the learning of statistical inference basic concepts for Spanish students in secondary level. This is part of an ongoing research project, with the aim to determine problematic areas, the students' difficulties, favourable learning environments or methodological questions that can serve like a base to the teaching of statistical inference in secondary schools.

3. Posters

Bakker, A. Statistical minitools in a learning trajectory. (Vol.1, p. 383).

A display to show the use of three very simple minitools (Java applets which can be downloaded from http://www.fi.uu.nl/~arthur), with well chosen problems, to develop statistical notions in an informal way. There is a progression from dot plots to histograms to scatter plots.

Müller H. & Lynnwood. L. Peer-assessment of data handling (gr 5's). (Vol.1, p. 409).

Observations by South African teachers of students, learning experiences when engaged in peer assessment of data handling activity. Students were required to assess each other's methods step by step.

Ritson, R. Finding links between early work in probability and the teaching of fractions. (Vol.1, p. 415).

Is it possible to link probabilistic ideas with early work on fractions? Yes. This answer results from a pilot study based on Irish primary-aged students.

Van Dooren, W., De Bock, D., Verschaffel, L. & Janssens, D. Searching for the illusion of linearity in probabilistic misconceptions: a literature review. (Vol.1 p. 421).

Investigation of misconceptions about proportion in geometry and then in probability has shown similar misconceptions in both areas. Empirical research based on the conceptual analysis is planned.

3. EUROPEAN WORKSHOP ON THE TEACHING AND DIFFUSION OF STATISTICS

Reported by Mauricio Beltrán, Instituto Balear de Estadística, mbeltran@ibae.caib.es

The General Council of Economy of the Balearic Islands Government (Spain), through the Balearic Institute of Statistics organised a two-day European Statistics Workshop on "The teaching and diffusion of statistics", which was held in Palma de Mallorca, October 10-11, with support by Eurostat and other European Statistical Offices. Conference topics included: Experiences in the diffusion and teaching of statistics, Statistics and the wider society, Statistical literacy, Attitudes towards statistics, Teaching of statistics, Statistical training for business and professional work, and Teaching resources: software, multimedia, Internet. Participants included over 70 representatives of the main national and regional statistical offices in Spain and other European countries, university lecturers and secondary school teachers. Presentations were organised in two main streams, each of them with some plenary presentations and a Round Table Discussion. Details are given below:

The teaching of statistics

- Statistical contents in the primary school mathematics curriculum. Alex Costa. Catalan Statistical Institute.
- Present and future of Statistics Education. Carmen Batanero. IASE.
- A new view about the teaching of statistics. Carlos Matrán, University of Valladolid.

- Initiatives to improve the teaching of statistics at University levels. M. Pilar Muñoz Gracia, Valeri Cobo et.al. University Polytechnics of Cataluña.
- Teaching materials. A problem-example in the introductory statistics course. F. Montes & M. Plaza. University of Valencia. University of Castilla - La Mancha
- The experience of Istat in the promotion of statistical literacy in schools. Giovanni Barbieri, Paola Giache. ISTAT.
- Round Table on the Teaching of Statistics. Antoni Montserrat, Economy Vicepresident of the Balearic Government; Catalina Juaneda, University of Balearic Island; Lourdes Llorens, Basque Statistical Institute, Miguel Castro, Spanish Statistical Institute and Carmen Batanero, IASE.

Statistical offices activities in the diffusion of statistics

- The European view of Statistics. Amador Rodríguez-Prieto. Eurostat
- The ALEA project. Teaching and Diffusion of statistics at Internet. Pedro Campos, Portuguese National Statistical Institute.
- Statistical information points. Antonio Rufián, Andalusian Statistical Institute.
- Reflections about the diffusion of statistics in small areas. José Luis Cervera. Valencian Institute of Statistics.
- Round Table on the Diffusion of Statistics. Antoni Montserrat, Economy Vicepresident of the Balearic Government; Antonio Argüeso, Spanish National Statistical Institute; Jordi Oliveres, Regional Statistical Institute of Catalonia; Pedro Campos, Portuguese National Statistical Institute; Amador Rodríguez Prieto EUROSTAT.

About 30 papers were received from Argentina, Chile, France, Israel, Italy, Portugal and Spain. The Institute is now producing a book with these papers, which will be published in their original language and will include a summary in Spanish, English, Catalan and French. More information is available from the Institute (ibae@caib.es) or, from the conference web page: http://www.caib.es/ibae/esdeveniment/jornades_10_01/main.html

4. REPORT ABOUT OZCOTS-4

Reported by Brian Phillips, BPhillips@groupwise.swin.edu.au

A two day Statistical Education Workshop was held on December 4 and 5, 2001, hosted by statistics@swinburne at the Swinburne University of Technology, Australia. The aim of this very successful series of meetings is to give anyone interested in statistics education the opportunity to hear what some of their colleagues have been doing in the past twelve months.

The Program consisted of workshops and regular presentations. The three workshops were:

- Excel Workshop, presented by Rodney Carr, Deakin University
- On-line workshop: "Live-to-Air Online Statistics Class" presented by Lyn Roberts, Robyn Pierce and Chris Turville, University of Ballarat
- PaceXL Workshop presented by Robin G Boyle, Deakin University

There was a session on "The statistical re-education of psychology" in which a number of researchers, including students, headed by Fiona Fidler, Geoff Cumming from La Trobe University gave the following talks:

- What can medicine teach psychology about statistical reform?
- Editorial influence on statistical practices in the Journal of Consulting and Clinical Psychology.
- Researchers' interpretation of graphically-presented confidence intervals and other error bars: Implications for replication.
- Researchers' interpretation of the width of graphically-presented confidence intervals and other error bars
- Inference by eye: Some rules of eye to guide the interpretation of graphically-presented confidence intervals and other error bars"

Regular presentations included:

- Brian Phillips, Swinburne University of Technology. *IASE events in 20*01
- Yong Goo Lee, Korea. *Teaching Statistical Concepts to young students using SPSS mapping*

- Peter Petocz and Anna Reid, University of Technology, Sydney and Macquarie University
- *How students experience statistics, learning statistics and teaching Statistics*
- Julie Pallant, Swinburne University of *Technology Developing a Scale of attitudes to Statistics*
- Peter Martin, University of Ballarat: *The Six Sigma Enigma*
- Alice Richardson, University of Canberra: *The beasts of the field, the fowls of the air and the fishes of the sea: estimation of population size*
- Ken Sharpe: University of Melbourne. *Detection of recombinant human erythropoietin (r-HuEPO) abuse in athletes*
- Neil Diamond and Ewa Sztendur, VUT *Teaching S-Plus for 1st Years*
- Rodney Carr, Deakin University *Some Issues In Teaching Statistics To Off campus students*
- Jason Giri, Peter Martin, Robyn Pierce, University of Ballarat *'Hypothetical' based around the work of Rev John Snow – for teaching nurses*

The presentations were of the highest standard with a number of presenters taking the opportunity to trial their proposed ICOTS-6 talk. If this is typical of what we can expect to hear at ICOTS-6, we are assured of a wonderful experience.

Some images of the sessions can be seen in the photo gallery of the OZCOTS4 site, http://www.swin.edu.au/maths/iase/ozcots4.html.

FORTHCOMING CONFERENCES

EARCOME 2002 - SEACME 9, Singapore, June 2002

The second ICMI-EARCOME (East Asia Regional Conference on Mathematics Education) is to be held in Singapore in June 2002. This conference, also designated as the Ninth Southeast Asian Conference on Mathematics Education or SEACME 9, has been officially recognized as an ICMI Regional Conference. It will be hosted by the National Institute of Education, Nanyang Technological University, Singapore and the Association of Mathematics Educators, Singapore. Information can be obtained from EARCOME 2002, Division of Mathematics, National Institute of Education,469 Bukit Timah Road,Singapore 259756, Republic of Singapore <earcome2@nie.edu.sg>.

Education and History Session at the Gnedenko Anniversary Meeting, Kiev, June 3-7 2002

This meeting is being held to commemorate the 90th anniversary of the birth of Boris Vladimirovich Gnedenko, the outstanding probabilist, writer, and teacher who died a few years ago. Details about the Meeting can be found on the Web site http://ln.com.ua/~tbimc/gnedenko. Teaching and education were central aspects of Gnedenko's life and work, reflected in his lectures, his textbooks and other educational writings, and his constant concern for the personal and mathematical development of his students. Reflecting this interest, one session of the Conference will be devoted to education and history issues.

Contributions with an educational theme, whether at school or tertiary level, would be welcome, the more so if they can reflect some facet of Gnedenko's interests. At the same time, I hope that the Meeting may provide an opportunity to stimulate interest in IASE activities among teachers and academic staff in countries of Eastern Europe, where Gnedenko did much to help restore programmes in probability amid statistics in the period following the second World War. More information from David Vere- Jones <david.vere-jones@vuw.ac.nz>.

International Conference on the Teaching of Mathematics at the Undergraduate Level Crete, Greece, 1-6 July, 2002

Following the very successful 1st International Conference on the Teaching of Mathematics (Samos, Greece, July 1998), the 2nd International Conference will address new ways of teaching undergraduate mathematics. It will provide a unique forum bringing together faculty from countries with varied educational systems who are committed to introducing innovative teaching methods and new pedagogies. The conference will be of great interest to mathematics faculty as well as anyone involved with the teaching and learning of mathematics. More information from Ignatios Vakalis, Dept of Math/Computer Science, Capital University, USA, <ivakalis@capital.edu>. Web site www.math.uoc.gr/~ictm2

The Sixth International Conference on Teaching Statistics. Cape Town, South Africa, 7 - 12 July 2002

The Conference is organised by the International Association for Statistical Education (IASE), the International Statistical Institute (ISI) and the South African Statistical Association (SASA). As the conference theme for ICOTS-6 is '*Developing a statistically literate society*', special sessions on statistical literacy are planned. A full description of all details for preparing ICOTS-6 papers, including periodic updates of the scientific programmes and papers abstracts is available in the ICOTS-6 IPC website (http://www.beeri.org.il/icots6/). LOC Web site: http://icots.itikzn.co.za/

For further details please contact: Maria-Gabriella Ottaviani <mariagabriella.ottaviani@uniroma1.it>, Brian Phillips, <bphillips@swin.edu.au> or Dani Ben-Zvi, <dani.ben-zvi@weizmann.ac.il>

VISIT-ME 2002. International Symposium on Integrating Technology into Mathematics Education, Vienna, Austria, 10-13 July 2002.

In 1992 ACDCA (the Austrian Center for Didactics of Computer Algebra) started a conference series which has become a driving force in bringing technology, in particular computer algebra systems (CAS), into the classroom. The conference series comprised two strands: the ACDCA Summer Academies, which were more oriented towards didactical questions connected with the use of technology for teaching and learning and the Int'l Derive (& TI-89/92) Conferences, which were more oriented towards concrete applications of these and similar tools for teaching in schools and at universities. In summer 2002 for the first time the two events will be held at the same place. Web site: www.kutzler.com/visit-me-2002.htm. More information from: <b.kutzler@eunet.at>

RELME. LatinoAmerican Meeting in Mathematics Education, Instituto Politécnico J. A. Echevarría, La Habana, Cuba, 15-19 July, 2002.

This conference is organised by the Latino American Committee for Mathematics Education. Activities are intended to share experiences and research on the teaching and learning of mathematics, including the teaching and learning of statistics and statistical thinking. Web site: http://www.cinvestav.mx/clame. More information is available from <ecarlos@ind.ispjae.edu.cu>.

26th Conference of the International Group for the Psychology of Mathematics Education, Norwich, UK, 21-26 July, 2002.

PME came into existence at the Third International Congress on Mathematics Education (ICME3) held in Karlsruhe, Germany in 1976. The major goals of the Group are:

- To promote international contacts and the exchange of scientific information in the psychology of mathematics education.
- To promote and stimulate interdisciplinary research in the aforesaid area with the co-operation of psychologists, mathematicians and mathematics educators.
- To further a deeper understanding into the psychological aspects of teaching and learning mathematics and the implications thereof.

The PME 26th conference will be held in Norwich, United Kingdom, at the campus of the University of East Anglia (see http://www.uea.ac.uk), from July 21st to July 26th, 2002. The Conference Chair is Anne Cockburn <a.cockburn@uea.ac.uk>. For further information visit the web site: http://www.uea.ac.uk/edu/pme26.

International Conference on The Humanistic Renaissance in Mathematics Education, Hotel Città del Mare, Terrasini, Palermo, Italy, September 20-25, 2002

The Sicily 2002 Conference is organised by the Facoltà di Scienze della Formazione dell'Università di Palermo, the Mathematics Education into the 21st Century Project - an international educational initiative whose coordinators are Dr. Alan Rogerson (Australia/Poland) and Professor Fayez Mina (Egypt). Since its inception in 1986, the Project has received support and funding from many educational bodies and institutions throughout the world. In 1992 UNESCO published our Project Handbook "Moving Into the 21st Century" as Volume 8 in the UNESCO series Studies In Mathematics Education.
Web site: http://math.unipa.it/~grim/21project.htm

PME-NA XXIV. Psychology of Mathematics Education. North American Chapter. University of Georgia, Athens, USA , October 26-29, 2002.

The purpose of the meeting is to provide a forum for scholarly discussion of central and current issues in mathematics education, particularly as they pertain to the role of psychology in mathematics education. English is the official language of the conference.

The theme for PME-NA XXIV is Linking Research and Practice. The conference will highlight examples of the interplay between research and practice–practice that has been shaped by research and research that grows out of practice. In addition, the plenary speakers will address areas in mathematics education where we need to look more critically at the links between research and practice.
Web site: http://www.pmena.org/2002

InterAmerican Conference on the Teaching of Statistics, Buenos Aires, Argentina, October, 28 to November 1, 2002.

This conference is organised by the Inter American Statistical Institute (IASI) and the Universidad Nacional Tres de Febrero, in connection with CLATSE V (Latino American Conference of Statistics), which is organised by the Argentinean, Chilean and Uruguayan Statistical Societies and the Argentinean Group of Biometry. Committee: Ana Haedo,María Teresa Blaconá (SAE), Susana Filippini, Laura Marangunich, and Ana Agulla (GAB),Roberto Muiños(IASI), Ernesto Rosa and Celina Curti (UNTREF).

More information from Celina Curti <ccurti@ciudad.com.ar>.

IV Mathematics Education Conference in Venezuela, Trujillo - Venezuela, November, 12- 16, 2002

This conference is organised by the National Association in Mathematics Education (ASOVEMAT). The aims are to continue the previous Mathematics Education Conferences COVEM, and to foster mathematics education research and practice development. There is a thematic group in the Teaching of Probability, Statistics and Combinatorics. More information from ivcovem@yahoo.eshttp://es.geocities.com/ivcovem/

Stochastic Thinking Group at the Third Conference of the European Society for Research in Mathematics Education (CERME 3), Bellaria , Italy, February 28th - March 3rd, 2003.

CERME is a conference organised by the European Society for Research in Education, and is designed to foster a communicative spirit. It deliberately and distinctively moves away from research presentations by individuals towards collaborative group work. The organisers for Group 5 (Stochastic Thinking) invite research-based papers on stochastic thinking, including probability, statistics and the interface between these domains. We will be particularly interested in theoretical, empirical or developmental papers that address one or more of the following themes (though any papers of relevance to the overall focus of the group will also be considered):

- The nature and development of stochastic thinking and its relationship to other types of mathematical thinking, including the interface between probabilistic and statistical thinking, such as in modelling or data exploration.
- The relationship between stochastic thinking and external factors such as teaching methodologies, tools, tasks and setting.
- The role of computer-based tools, including microworlds, on stochastic thinking.
- The elaboration of theoretical frameworks that may provide insightful models for interpreting evidence from research on stochastic thinking.

Details of conference and format for papers are given on the CERME3 web site http://fibonacci.dm.unipi.it/~didattica/CERME3/. More information available from the organisers: Dave Pratt (Group 5 Coordinator); <dave.pratt@warwick.ac.uk>, Carmen Batanero <batanero@goliat.ugr.es>, Rolf Biehler <biehler@mathematik.uni-kassel.de> and Michel Henry <michel.henry@univ-fcomte.fr>

IASE Satellite Conference on Statistics Education and the Internet, Max-Planck Institute for Human Development, Berlin, 11-12 August 2003

This conference will be organised by the IASE in Cupertino with the Section on Stochastics of the German Mathematics Education Association, the Max-Planck-Institute for Human Development, and the Stochastics Section of German Mathematical Association. The aim is to discuss the implications of the Internet for teaching and learning statistics: web based teaching, learning, materials and resources.

An electronic proceedings and a limited number of printed copies of the set of papers presented will be produced after the conference.

More information from: the Chair Larry Weldon <weldon@sfu.ca> or the Chair of the Local Organising Committee, Joachim Engel <JoaEngel@aol.com>. Web page: www.ph-ludwigsburg/iase

IASE IPM at ISI-54 Berlin, Germany, August 13-20, 2003

The list of IASE Invited Paper Meetings for Berlin is finished. In addition to a proposed exhibition "History of statistics and its teaching" organised by Maria-Gabriella Ottaviani mariagabriella.ottaviani@uniroma1.it. The following Invited Papers Meeting will be organised:

- IPM44 Teaching probability with a modelling approach. Organiser: Michel Henry <henry@math.univ-fcomte.fr>
- IPM45 Statistics training for consultants or collaborators. Organiser: Gabriella Belli <gbelli@vt.edu>.
- IPM46 International co-operation in research on statistics education. Organizer: Lisbeth Cordani <lisbeth@maua.br>.
- IPM47 Mathematics teachers teaching statistics. Organiser: Susan Starkings <starkisa@sbu.ac.uk>.
- IPM48 Statistics education for media reports. Organiser: Maxine Pfannkuch <pfannkuc@math.auckland.ac.nz>.
- IPM49 Teaching and learning approaches aimed at developing statistical reasoning, thinking or literacy organisers: Joan Garfield <jbg@tc.umn.edu> and Dani Ben-Zvi <dani.ben-zvi@weizmann.ac.il> .
- IPM50 Statistics Teaching in the Internet Age. Organiser: Wolfgang Haerdle <haerdle@wiwi.hu-berlin.de>.

- IPM68 Assessment of literacy, numeracy and other life skills. Organiser: Denise Lievesly <d.lievesly@unesco.org>.
- IPM69 Impact of developments in information systems on statistics education (joint with IASC). Organiser: Annie Morin <Annie.Morin@irisa.fr> and Albert Prat
- IPM70 Teaching biostatistics (joint with the International Biometrics Society). Organiser: Elisabeth Svensson <elisabeth.svensson@esa.oru.se> and Els Goetghebeur.
- IPM71 Educational implications of statistical methods and modelling developments in psychometry. (Joint with the European Mathematical Psychology Group). Organiser: Helena Bacelar <hbacelar@fc.ul.pt> and Francesca Cristante.

Interested people are invited to contact the above mentioned organisers or the Chair of the IASE Programme Committee Gilberte Schuyten, Gilberte.Schuyten@rug.ac.be

The 10th International Congress on Mathematics Education, July 4-11, 2004, Copenhagen

The congress will take place July 4-11 2004 - The venue will be the Technical University of Denmark, located in a northern suburb of Copenhagen. The IASE will be collaborating in the organisation of specific statistics education activities in the conference. Chair International Programme Committee: Mogens Niss <ICME10-IPC@ruc.dk>. Chair Local Organising Committee Morten Blomhøj <ICME10-LOC@ruc.dk>. Conference web page: http://www.icme-10.dk/