Statistical Education Research Newsletter

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1. Notes and Comments

This was a productive summer where many of us had the chance of meeting again, this time at the conferences with statistical education components which were held in Japan. There we had the opportunity to learn more about statistics and statistics education in Japan, as well as to enrich our knowledge about the country—its culture, traditions, art and people—and appreciate the Japanese wonderful hospitality. We are reporting on these and other conferences in the USA, France and Australia.

At the *IASE Round Table Conference* problems concerning the training of researchers in the use of statistics were discussed. Surveys carried out by researchers and consultants, analyses of statistical methods used in research literature, and descriptions of courses for researchers suggested the variety and complexity of statistical topics which are currently needed for research in almost all areas of knowledge. It was also observed that much more research is needed on this topic, because consultancy work is not always valued as it should be, and statistics is often misunderstood and misused by researchers, not only when using advanced methods such as stochastic processes or multivariate analysis, but also with basic concepts such as association or statistical tests. The Round Table work will continue after the conference, and a monograph on the theme will be produced by the *IASE* in 2001, which will contain the refereed papers and discussions at the conference. Other major events where the *Teaching and Learning of Statistics* Topic Study Group at *ICME 9* organised by Susan STARKINGS, on behalf of *IASE* and the *PME-24*, where a number of presentations in stochastics and a Stochastics Discussion Group were held.

We are reporting other statistical education activities around the world, including conference announcements, dissertations and research report summaries. Please pay special attention to the forthcoming *ICOTS VI*, as it is now time to offer for participation in the invited papers sessions, where we are looking forward to receiving your contributions. The *PME 25, ISI 53 Session and SRTL-2 Forum* are other opportunities for letting us know more about your work and research.

Plans for the *IASE Statistics Education Research Group (SERG)* are still evolving. Recent discussions among the *IASE* Executive Committee have focused on the role of *IASE SERG* in holding small, focused, research fora. In addition to *IASE Round Table* conferences which are only held every four years in connection with *ICME* conferences and which are more formal conferences requiring much planning and preparation, the *IASE Executive* has decided to give our group responsibility for endorsing and co-ordinating occasional research fora (such as the *International Research Forum on Statistical Reasoning, Thinking and Literacy, SRTL-1,* held in Israel last summer). The *Second International Research Forum on Statistical Reasoning, Thinking, and Literacy (SRTL-2)* will be supported by *IASE* under the banner of *SERG.*

Additional fora will be organised to complement the *IASE Round Table Conferences,* linking them with the *ISI* sessions every two years starting from *ISI 54* in Berlin. These *IASE* endorsed conferences or fora will begin to charge non-*IASE* Members a sum of money above the standard rate which would pay for one year's membership of *IASE*. The four of us will act as the starting organising committee for this group and we will be pleased to accept your co-operation and suggestions as regards any initiative leading to develop research in statistical education.

<u>Notes</u>: Throughout the Newsletter, *IASE* members' names are highlighted in capital letters.

The whole Newsletter is located at the web site: <u>http://www.ugr.es/local/batanero/sergroup.htm</u>

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2. *IASE* Members

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Assumpta is working in mathematics education, at the Faculty of Education in Lleida, Spain. She did a Master's thesis on students' attitudes towards statistics (we are including the summary in this issue). In view of the results, she is planning to continue with this topic. Even when the relevance of statistics in education and society is widely recognised, statistics is frequently forgotten by teachers in Spain, since future teachers enter the

University with little preparation in this topic. Assumpta considers there is an underlying attitude problem. Different educational studies suggest that attitudes are shaped according to different pedagogical components, and to the social and cultural environment of teachers and students. In her current work she is trying to analyse the effect of the different pedagogical and anthropological components of attitudes towards statistics and to evaluate the relationships between them.

Roger W. JOHNSON
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Roger's dissertation work concerned extensions of the James-Stein estimator to other than the normal distribution case; publications of his along this line may be found at his web page: http://silver.sdsmt.edu/~rwjohnso/techpub.html. His recent work, however, is focused on pedagogical matters. Such work includes (i) finding interesting data sets for students to explore (e.g. NFL quarterback statistics, body fat data, word frequencies in texts), (ii) work on including technology in the classroom (including the TI-83/83+ in the classroom – see http://silver.sdsmt.edu/~rwjohnso/Ggrant.htm), and (iii) the use of active learning in the classroom (with some published articles involving such at http://silver.sdsmt.edu/~rwjohnso/edpub.html).

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Nora's work is centred on Multivariate Data Analysis, in line with the French school of research. She is a senior lecturer teaching data analysis to students in social communication at the Universidad Nacional de Rosario. Her approach is based on emphasising the articulation of statistical techniques with research methods in social sciences.

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Milo's primary focus is on "statistical literacy": the use of statistics as evidence for the truth of disputable claims (critical thinking about statistics). Statistical literacy is viewed as including not only traditional statistical inference (deduction) but also the use of observational statistics in arguments concerning causation (induction). Milo spent a sabbatical at the *RSS Centre for Statistical Education* (Nottingham). Copies of his papers on statistical literacy (ICME-9), Simpson's Paradox, Bayesian reasoning (ICOTS-5) and grammar are available on his web site. Milo is currently teaching introductory statistics (business majors), critical thinking (graduate students), and statistical literacy (humanities majors). He has organized sessions on statistical literacy at the *Joint Statistical Meetings* of the *American Statistical Association.*

3. Brief News

Results of Voting on *IASE* Statutes

In a recent survey of *IASE* members concerning some changes to the *IASE* statutes, the following motions have been approved:

1. The number of Vice Presidents have been increased from 4 to 5.

2. The immediate past president will be a member of the Executive Committee.

3. The category of honorary membership was created.

These welcome changes will assist the executive carry out the increasing number of tasks it has to deal with. The *IASE* Executive Committee would like to thank those members who supported these proposals.

Mathematics Futures

Helen MACGILLIVRAY <h.macgillivray@fsc.qut.edu.au>, President of the *Australian Mathematical Sciences Council* and Board Member, *Federation of Australian Scientific and Technological Societies (FASTS)* runs a number of maths extension/enrichment in maths programs, and one of them is *"Mathematics Futures"* which is run each year during Australia's National Science Week. Helen gets a range of young mathematics/statistics graduates to speak briefly about their work, their career aspirations and how they came to do maths/stats. The audience is final year school students and their teachers and there have been about 200 each year. It is a lot of fun and the school students and teachers love it and find it very valuable. Please note that the talks just mention maths but a lot of them are of course statistics, and it is also an opportunity to show them that statistics is much more than they could have imagined. This is the programme in the last event:

- Welcome by Tony Pettitt, and introductory remarks from Mr Rowan Ward;
- Celina Harlow, *Maths as a facilitator in IT and the workplace;*
- Simon Sando, *Mathematically speaking;*
- Tanya Jeffress, *From economics to maths to risk analysis;*
- Troy Farrell, *Modelling alkaline batteries;*
- Bronwyn Norrie, *So many real problems that need maths skills;*
- Joel Hockey, *On the interface of maths and I.T;*
- Sonia Knight, *Fish, genetics and more;*
- Peter Coutis, *Tropical cyclones and cricket balls: what could they possibly have in common;*
- Mary Whateley, *From aphids and ladybugs to gliders and owls;*
- Helen MACGILLIVRAY Closing remarks and *"Back to earth: school to university"*.

New statistical education section at the journal *Statistics in Transition* (Poland)

Jan KORDOS <J.Kordos@stat.gov.pl> announces that, starting from June 2000, a new section on "Statistical Education" was opened in the Polish international journal (published in English) *Statistics in Transition.* In the June issue a paper by Jan was included entitled "On Tasks and Activities of the International Association for Statistical Education", *Statistics in Transition,* 4(5), pp. 901-904, June 2000.

In next issues various papers, information, discussions, opinions, etc. related to statistical education in different countries, particularly transition countries, will be published. Interest is focussed on such topics as: a) teaching statistics at all levels, b) training statistical staff for government statistical offices, c) developing statistical textbooks, d) audio-visual materials for statistical education, and e) curricula. Jan invites *IASE* members to send their contributions to this section.

Invitation from the International Journal of Computers for Mathematical Learning.

Michéle Artigue, editor of *International Journal of Computers for Mathematical Learning* <artigue@math.jussieu.fr> invites *IASE* members to submit research papers of interest to the journal's audience. She is particularly looking for good quality research papers which present results of empirical studies on the teaching and learning of statistics based on the use of computers and which are based on a solid theoretical and epistemological background.

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4. Summaries of Publications by *IASE* Members

CALLAERT, H. (2000). Amazing graphs. *Teaching Statistics,* 22(1), 25-27. A cautionary tale about habits in graphical displays.

ESTRADA, A. (In press). Actitudes y estadistica [Attitudes and statistics]. *UNO.* Despite appearing in the compulsory teaching programs and its recognised usefulness in society, statistics is often forgotten by teachers. In the author's opinion this is due to teachers' negative attitudes towards the subject which are transferred to the students. Starting from these premises, we are beginning a study of attitudes towards

statistics, with the aim of designing a measurement instrument which allows us to know the attitudes towards the statistics of in service and future teachers.

ESTRADA, A. (In press). Estudio de actitudes hacia la estadística [A study of attitudes towards statistics]. *Suma.* The relevance of statistics in compulsory education is widely recognised in society and other disciplines. This contrasts with the poor training of future primary teachers in Spain. When reflecting on this reality we realise the need for greater scientific knowledge and in trying to find possible causes we deduce from studies carried out in other countries that there is a problem of attitudes. We are therefore planning to study the attitudes towards statistics from primary teachers in future teachers to assess whether a negative attitude is also found in our context.

GALLESE, E. (2000). Carlos E. Dieulefait. 1901-1982. Su obra [Works of Carlos E. Dieulefait. 1901-1982]. Paper to be presented at the *Coloquio Anual de la Sociedad Argentina de Estadistica*, Misiones, Agosto, 2000. On the occasion of the 100th anniversary of Dieulefait, born 27 July 2001, who was a scientist and promoted different institutions, I am trying to make his work more widely known. He published in the Journal *Filosofía*: "La Matemática y la Realidad [Mathematics and reality]", "La Matemática y la Lógica [Mathematics and logic]" and "Philosophical principles of statistics" in the twenties. He also published in *Biometrika* (University of London) *Metron* (University of Rome), *Comptes Rendus* (Academy of Sciences, Paris), *Revista Estadística* (Brazilian Institute of Statistics), and *Annals of Mathematical Statistics.* He was honorary member of the *French Statistical Society*, the *English Royal Statistical Society* and Fellow member of the *American Statistical Institute.* He preferred among his papers two studies on correlation "Sur la correlation au sens modes" presented to the French Academy of Sciences with Emile Borel and "Contribution a l´étude de la théorie de la corrélation" [Contribution to the theory of correlation] published in *Biometrika.* He was cofounder in 1940 of *IASI (Inter American Statistical Institute),* and was honorary president of the same. In 1947 he proposed to this institute a curriculum for training statisticians in Argentina, which was the base for the creation in 1948 of a Major in Mathematical Statistics. In this work I will comment on his "Application of Average Values" published at the proceedings of the *Argentinean Statistical Society* in 1930.

HUBERTY, C. J. (2000). Assessment of student performance in statistics. *Teaching Statistics,* 22(2), 44-48. This article describes assessment and scoring methods that have been used successfully in graduate-level statistics teaching.

JOHNSON, R. W. (In press). Illustrating conditional calculations with 'Jolly Roger', *The Mathematical Gazette* March 2001, volume 85. Shows how iterated expectation rules may be used in divide and conquer fashion to compute the expected score and the standard deviation of score in the dice game 'Jolly Roger'.

JOHNSON, R. W. (2000). Sampling without replacement, *Mathematics Teacher, 93,* November. Shows how the TI-83/83+/89/92 may be programmed to perform sampling without replacement. Applications include choosing lottery numbers.

JOHNSON, R. W. (2000). Investigating randomness via simulation using the TI-83, *Teaching Statistics, 22*(3). Presents four different probability puzzles with nonintuitive solutions and gives the results of TI-83 programs (available from the author) in an attempt to convince sceptical students.

KORDOS, J. (2000). Permanentne szkolenie statystyków [Permanent training of statisticians]. *Wiadomosci Statystyczne,* 6, 2000, 50-62. The author discusses problems connected with training of statisticians at statistical offices and highlights the need for permanent training at different levels. He describes in general outline the problems of statistical education discussed at the *52nd Session of ISI* in Helsinki—mainly at meetings organised by the *International Association for Statistical Education.* Next he presents outlines of statistical training system, discussing such components as: (a) training programmes and their contents; (b) lecturers and their experience; (c) participants in the training; d) organisation of the training and didactic assistance—especially training and books and video films; (e) methods of evaluating training results. Training programmes and their contents are discussed in detail with a specification of 16 major subjects of statistical training. The author draws conclusions about what demands should be met in order to introduce statistical training effectively into practice.

LAMPRECHT, T. (1998). Computer aided instruction: evaluation of UNISA STA101-H CAI lessons - Set theory and probability. *Vista Occasional Papers (VOC),* 6(1), 40-52. As part of the distance education course for first year statistics students at the University of South Africa (UNISA), a series of computer-aided instruction (CAI) tutorial lessons was developed. An evaluation of two of the lessons in the series, which was carried out at Vista University, indicated that they were positively received by the participating

students. The students are all second language English speakers, with an African language being their home language. The language level, the difficulty level and pace of the CAI lessons are appropriate for the target audience.

LAMPRECHT, T. (1999). Critical evaluation of the assessment strategy in teaching statistics at Vista University within an outcomes based approach. *VITAL, 13(1).* The South African Qualifications Authority determines that there should be a paradigm shift in education; specifically that there should be a shift from content measurement to performance assessment. The introductory statistics course, STM100, is critically evaluated and suggestions made to change assessment to be in line with the new system. The question is asked: "Can students apply their knowledge to solving statistical problems if the assessment method is only paper based?" A method of providing students with timely, constructive feedback is given. Applying performance assessment and authentic assessment in teaching statistics is discussed. In the STEPS (STatistical Education through Problem Solving) project students are given assignments to do a real analyses of data. This is "real life" performance assessment where the lecturer can determine whether students can reason with statistical concepts.

Lawner W., S., & ABRAMOWITZ, S. (2000). Making general principles come alive in the classroom using an active case studies approach. *Journal of Statistical Education,* 8 (2). Five case studies based on real situations and real data are presented for use in courses on research methodology and data analysis. Departing from the typical case study approach, students are asked to act as consultants to resolve the issues placed before them, prior to being given a solution. In generic terms, students are given a description of a real problem and a real data set relevant to solving that problem and are asked for their advice on how the problem may be solved. This approach motivates students to take ownership of the problem at hand and provides them with the opportunities and experiences to use the tools of their education actively, rather than to merely acquire them.

LEE, C. (In press). A paradigm shift in the technology era in higher education. To appear in the *Proceedings of the ED-MEDIA 2000,* Association for the Advancement of Computing in Education, Montreal, CA, June 26th to July 1st 2000. This article presents a paradigm shift from the traditional curriculum model of setting goals and objectives to a new curriculum model of setting standards and responsibilities to assist instructors and students in changing from teacher-centred learning to student-centred learning in the technology era. The student-centred learning environment is diverse and allows students with different learning styles and intellectual abilities to prosper at their own pace. Teaching pedagogy and classroom learning are much behind the evolving of technology. In the advanced technology era, not only the traditional lecture and note taking approach will be seriously challenged, but also the static use of technology will be seriously challenged as well. This article addresses two fundamental obstacles in shifting from teaching-centred to learning-centred strategy in technology era at higher education. A case study on introductory statistics is presented to illustrate how to deal with these fundamental obstacles.

LEE, C. (1999). Computer-assisted approach for teaching statistical concepts. *Journal of Computers in Schools,* 193-208. Many students consider statistics to be one of the most difficult and boring subjects in their college experience. Because of this, statistics educators have begun to rethink how students learn statistics and how to teach the basic concepts of statistics. In this article we present an approach for teaching and learning statistical concepts by implementing computer-assisted hands-on activities that emphasise the process of guided leaning and knowledge discovery. The computer-assisted approach consists of five essential components: hands-on activities, co-operative learning, self-selected projects, computer technology and exercises. The approach is designed to help students to acquire statistical reasoning and problem solving skills. The emphasis is on statistical reasoning before data are collected and the presentation of results after data are analysed. Computer technology is the essential tool integrated into the entire learning process. Students are at the centre of the learning process. Instructors play the role of facilitator and guide students through the process of active learning.

LEE, C. (1999). Student's perspective in introductory statistics - attitudes, pedagogy and contents. *Proceedings of the American Statistical Association, Section Statistical Education,* 1999, Baltimore, MA, August. Statistics is considered by many college students one of the most boring and difficult subjects in their college experience. Reasons that are attributed to this attitude may include both cognitive factors and non-cognitive factors. An interview study was conducted to investigate student attitudes, learning styles, and their perspective about instructional pedagogy and the contents that they learned from the course. Of particular interest is to investigate the relationship between attitudes, learning styles and their perspective about the instructional pedagogy. Students from two classes were interviewed. One used the traditional

lecture approach. The other used hands-on activities in a computer class room environment. A comparison will be made to investigate the differences between these types of pedagogy.

MOORE, D. S. (1998). Statistics among the liberal arts. *Journal of the American Statistical Association*, 93 (444), 1253-1259.The liberal arts are usually understood to be general and flexible modes of reasoning. By this definition, statistics qualifies as a liberal art, and it is important to the health of the discipline that it be recognised as such. The "philosophical" tradition of the liberal arts that is now dominant has alternated with an "oratorical" tradition that also gives insight, as do ideas of "evolutionary psychology." This paper considers how understanding statistics as a liberal art influences our appreciation of the discipline and especially our teaching of beginners.

ROSSMAN, A., & CHANCE, B. (1999). Teaching the reasoning of statistical inference: a "top ten" list. *College Mathematics Journal* 30(4), 297-305. Introductory statistics courses should focus on student experiences with data and understanding of fundamental concepts. E.g.: Have students perform physical simulations; encourage students to use technology; present tests of significance in terms of p-values rather than rejection regions.

WATSON, J M., & Moritz, J. B. (2000). Developing concepts of sampling. *Journal for Research in Mathematics Education,* 31(1), 44-70. A key element in developing ideas associated with statistical inference involves developing concepts of sampling. The objective of this research was 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 analysed. Responses were characterised 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.

5. Bernd Wollring's Work Into Probability Learning

John Truran

Bernd Wollring is now a Professor at the University of Kassel, Germany. His Habilitation thesis was prepared at the University of Münster, Germany on the probabilistic understanding of young children, and he has published a small number of papers on this topic. But although he speaks good English, he has not published in English, and so his work has been little noticed in most parts of the world. This brief notice here is included in the belief that it will be of special interest to some of our readers. The thesis is entitled:

Wollring, Bernd (1994) *Qualitative empirische Untersuchungen zum Wahrscheinlichkeitsverständnis bei Vor- und Grundschulkindern* [Qualitative empirical investigations into the probabilistic understanding of pre-school and primary school children] Habilitation Thesis: Westfälischen Wilhelms-Universität Münster

The work uses a qualitative approach to report and analyse the decisions of pre-school and primary school children in stochastic situations in order to see how their conceptions might be used to develop a teaching programme. It looks at how pre-school and primary school children behave in stochastically based games, how they talk about their risk-taking decisions, and what conclusions they draw from their experiences. Its approach is competency oriented, not deficit oriented, and developed within a Constructivist perspective.

The data takes the form of a very large number of video-taped interviews of game situations with pre-school and primary school children.. These include simple race-track and board games, and utilise very carefully prepared random generators, including modified roulette wheels and a child-proof urn model made from old audio-tape holders. All of the interviews have been subjected to very detailed analysis with the aim of establishing answers to questions like:

- how children articulate the distinction between random generators and an appreciation of their properties in risk-taking situations;

- whether children are capable of stochastic model-building and what conditions and experiences control their stochastic model-building capabilities;

- the effect of the interaction between the random generator and its outcomes on children's model-building skills;

- what is necessary to convey stochastic understanding to children;

- the relationship between stochastic understanding and arithmetical skills.

These are questions which many of us have addressed in a variety of ways, but few of us have managed to assemble a data-base as large as Wollring's, and very few have been as thorough in our analysis of the data. Even with such a large data base Wollring has only been able to provide some answers to these questions and not an over-arching theory, but he has been able to add new perspectives, arising both from his methodology and the imaginative games which he has developed.

One really important contribution of his thesis is the extraordinarily detailed and insightful analysis which he has done on his transcripts. They are a model for anyone who wants to undertake careful analysis of clinical interviews. A second contribution is his findings about the value of using clinical interviews in the preparation of teachers. His work was supported by a large number of students, and he has found that their teaching skills benefited from the interviews they conducted for him.

Works by Wollring which are a little more accessible than his thesis include

Wollring, B. (1993). Spielinterviews zur Erkundung stochastischer Vorstellungen bei Kindern in Vor- und Grundschulalter [Clinical interviews using games as part of an enquiry into the stochastic understanding of pre-school and primary school children]. Pp. 67–91 in Lorenz, J.H. (Ed.) *Mathematik und Anschauung*, IDM-Reihe Band 18.

Wollring, B. (1994). Animistische Vorstellungen von Vor- und Grundschulkindern in Stochastischen Situationem [Animistic beliefs among pre-school and primary school children in stochastic situations]. *Journal für Mathematik Didaktik,* 15, 3–34.

I am grateful to Dr Professor Bernd Wollring for sharing many of his ideas with me when he was in Münster, and to Dr Andrea Peter-Koop, University of Münster, for making a copy of the thesis for me. My German is not at all strong, but this should indicate the flavour of Bernd's work. Some of this note is direct translation, and some is personal commentary, but the two are not distinguished here.

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6. Recent Dissertations

ESTRADA, A. (1999). Análisis de actitudes hacia la estadística. [An analysis of attitudes towards statistics]. Masters thesis. Universitat Autònoma de Barcelona. Supervisor: Josep Mª Fortuny i Aimeny

A look at the history of mathematics helps us to realise the long journey from statistics first steps to its present situation where it is considered essential for the training of citizens. This relevance of statistics in compulsory education contrasts with poor knowledge about it by student-teachers. As a lecturer of this topic, I tried by using different sources of information (summer schools, seminars, in-practice students) to find out the causes of this situation which lead to the absence of the teaching of statistics in the majority of real curricula. I also observe that in places cases where it is taught, neither the methodology nor the view presented of statistics is adequate. Therefore, the new curricular reform has not solved the problem of introducing statistics at the first teaching levels and does not cover the students' needs.

This finding has led me to start a research about attitudes, since I think there is an underlying attitude problem and, at the same time, research in different cultural contexts has shown negative attitudes towards mathematics on the part of future teachers. In this thesis I try to assess student-teachers' and service-teachers' attitudes towards statistics, through an adequate measurement instrument and through data analysis. I compare the attitudes towards statistics with results regarding attitudes towards mathematics described in previous research.

Roa, R. (2000). *Razonamiento combinatorio en estudiantes con preparación matemática avanzada* [Combinatorial reasoning in students with high mathematical training]. Ph.D. Thesis. University of Granada. Supervisors: Juan D. GODINO, & Carmen BATANERO.

This thesis continues the work carried out by Navarro-Pelayo (1994), who studied the 14-15 years-old secondary students' strategies, errors and difficulties in solving elementary combinatorial problems by comparing 352 students who had previously studied combinatorics with 368 students with no instruction on this topic.

As a result this research was centred on characterising the difficulties and errors in solving elementary (single and compound) combinatorial problems in students with high mathematical training, using different task variables.The research methodology included written questionnaires, clinical interviews and semiotic analysis of students' written productions. All the students in the different samples were in their 4th or 5th year of University studies and were majoring in Mathematics. The questionnaire used by Navarro-Pelayo was first given to 27 students. After their responses were analysed, the questionnaire was revised to include two compound problems and was given to a second sample of 29 students. Thirdly, a theoretical *a priori* analysis of two different types of reasoning which might be applied in solving the tasks in the second questionnaire served to establish the hypotheses and to build a system to analyse the students' reasoning. In the fourth, confirmatory, stage the revised questionnaire was given to 91 students and served to estimate the effect of the different task variables on the difficulty of problems, as well as to characterise the different interpretations of the problem statement and the different solving strategies. The author found a significant effect of combinatorial operation and size of parameters, but found no significant effect of the combinatorial model on the difficulty of problems.

Finally four students were selected to perform a case study which focussed on an analysis of students' reasoning in solving the problems and of their responses to interviews. The results show that University students have major difficulties in solving elementary combinatorial problems and in some problems their achievement is not different from that of secondary students. This is due to the complex structure of the solving processes required which was shown in the semiotic analysis of these processes There were no major differences in the performance in solving combinatorial problems among students who use formulae and those who prefer enumerative strategies. Key points in explaining errors were the incorrect interpretation of the problem statement, the lack of enumerative and recursive capacities and the incorrect use of strategies, such as dividing the problem, translating the statement and generalising. These results should be recognised when organising teaching, which should emphasise the modelling process, the recursive reasoning, solving and enumeration strategies instead of being reduced to algorithmic aspects and on the definition of combinatorial operations.

Reference

Navarro-Pelayo, V. (1994). *Estructura de los problemas combinatorios simples y del razonamiento combinatorio en alumnos de secundaria* [Structure of single combinatorial problems and of secondary students's combinatorial reasoning]. Doctoral Thesis. Universidad de Granada

WILLIAMS, A. (1999). *Students' understanding of hypothesis testing in introductory teartiary-level statistics.* Unpublished PhD Thesis, Queensland University of Technology. Supervisors: Bill Atweh and Lyn English.

The research study investigates students' understanding of hypothesis testing by exploring their conceptual and procedural knowledge of the topic.

Eighteen volunteer students from a large introductory service subject in statistics were interviewed three times during their semester of study—at the beginning of the semester, several weeks after their introduction to the topic of hypothesis testing, and after the final exam in the subject. This thesis reports mainly on the results from the third interview, in which students were required to complete a Concept Mapping task and two Hypothesis Testing tasks while talking aloud. On completion of each task, students were interviewed about their responses on these tasks. The focus is on four main concepts (hypothesis, significance level, p-value, significance) and the process of hypothesis testing. Students' protocols were analysed, and three case studies provided a deeper analysis of overall responses. Qualitative methods were used in the collection and analysis of data.

The study revealed that while some students had a good understanding of the hypothesis testing concepts and procedures, there were many deficiencies. In particular, students were often unable to define or explain a concept, give an example, or describe its relationships with other concepts. Less than half of the students could complete an Hypothesis Testing task by an approved method, and several solutions were incorrect at the

decision step. There was evidence of some problems with statistical notation, and it was found that each procedural step in the hypothesis testing process had the potential to present difficulties. An overriding problem was associated with expressing ideas with statistical accuracy. The case studies confirmed that the relationship between conceptual and procedural knowledge was an interactive one. This was an important finding in the thesis. The relationship between conceptual and procedural knowledge was found to be so close that one type of knowledge depended on the other, particularly in performing Hypothesis Testing tasks. In addition, metacognition is needed to access the conceptual knowledge, which in turn improves the procedures.

This study provides empirical support for the move away from hand-worked hypothesis tests to an emphasis on the development of concepts. From the research, suggestions are offered for teaching with the latter emphasis, and improving students' overall understanding.

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7. Bibliography on Assessment

Compiled by Joan GARFIELD, Iddo Gal and Beth CHANCE

The following bibliography is a combined list based on:

Gal, I., & GARFIELD, J. (Eds.) (1997). *The Assessment Challenge in Statistics Education.* Amsterdam: IOS Press and GARFIELD, J. & CHANCE, B. (2000): "Assessment in Statistics Education: Issues and Challenges". *Mathematics Thinking and Learning,* 2(1/2), 99–126,

and so constitutes a very broad summary of what is currently seen as important in the assessment of statistical understanding. You will notice that not all of the items on this list are specifically on the topic of assessment.This is because the references are those cited in the two publications and may refer to other aspects of statistics education as well as to the assessment of student learning.The book on Assessment is still in print, and is obtainable for USD65 from the ISI office <market@iospress.nl>, or through bookshops (ISBN 90 5199 333 1).

Allwood, C. M., & Montgomery, H. (1981). Knowledge and technique in statistical problem solving. *European Journal of Science Education, 3,* 431-450.

Allwood, C. M., & Montgomery, H. (1982). Detection of errors in statistical problem solving. *Scandinavian Journal of Psychology, 23,* 131-140.

American Association for the Advancement of Science (Project 2061) (1993). *Benchmarks for science literacy.* New York: Oxford University Press.

American Statistical Association-National Council of Teachers of Mathematics (ASA-NCTM) (1994). *Teaching statistics: Guidelines for elementary through high-school.* (G. BURRILL, Editor). Palo Alto, CA: Dale Seymour Publications.

Anderson, C. W. & Loynes, R. M. (1987). *The teaching of practical statistics.* Chichester & New York: John Wiley.

Anderson, S, Ball, S., Murphy, R., & Associates. (1975). *Encyclopedia of educational evaluation.* San Francisco: Jossey-Bass.

Angelo, T., & Cross, K. P. (1993*). Classroom assessment techniques.* San Francisco: Jossey-Bass.

Arter, J. & Spandel, V. (1992). Using portfolios of student work in instruction and assessment. *Educational Measurement: Issues and Practice, 11*(1), 36-44.

Artzt, A. F. & Armour-Thomas, E. (1992). Development of a cognitive-metacognitive framework for protocol analysis of mathematical problem solving in small groups. *Cognition and Instruction, 9,* 137-175.

Artzt, A. F. (1994, February). Integrating writing and cooperative learning in the mathematics class. *Mathematics Teacher, 87,* 80-85.

Australian Education Council. (1991). *A national statement on mathematics for Australian schools.* Canberra: Curriculum Corporation.

Australian Education Council (1994a). *A statement on studies of society and environment for Australian schools.* Carlton, Vic.: Curriculum Corporation.

Australian Education Council (1994b). *Studies of society and environment – a curriculum profile for Australian schools.* Carlton, Vic.: Curriculum Corporation.

Baker, E. L. (1990). Developing comprehensive assessments of higher order thinking. In G. Kulm (Ed.), *Assessing higher order thinking in mathematics* (pp. 7-20). Washington, DC: American Association for the Advancement of Science.

Baker, E. L., Aschbacher, P. R., Niemi, D., & Sato, E. (1992). CRESST Performance assessment models: Assessing content area explanations. Los Angeles: CRESST.

Baker, E. L., Freeman, M., & Clayton, S. (1991). Cognitively sensitive assessment of subject matter. In M. C. Wittrock, & E. L. Baker (Eds.), *Testing and cognition.* New York: Prentice-Hall.

BATANERO, C., GODINO, J. D., & Navarro-Pelayo, V. (1994). *Razonamiento combinatorio* [Combinatorial reasoning]. Madrid: Síntesis.

BATANERO, C., Navarro-Pelayo, V., & GODINO, J. (1997). Effect of the implicit combinatorial model on combinatorial reasoning of secondary school students. *Educational Studies in Mathematics,* 32, 181-199.

BEGG, A. (1991). Assessment and constructivism. *New Zealand Mathematics Magazine. 28*(2), 14-20.

Beck. C. T. (1986). Use of nonparametric correlation analysis in graduate students research projects. *Journal of Nursing Education, 25,* 41-42.

BEN-ZVI, D. (1999, August). Alternative assessment in statistics education. Discussion of assessment papers presented at the *Fifty-second International Statistical Institute Session*, Helsinki, Finland.

BEN-ZVI, D., & Friedlander, A. (1997). Statistical thinking in a technological environment. In J. B. GARFIELD, & G. BURRILL (Eds*.), Research on the role of technology in teaching and learning statistics: Proceedings of the 1996 IAE Round Table Conference.* Voorburg, The Netherlands: International Statistical Institute.

Bentz, H. J., & BOROVCNIK, M. G. (1988). *Empirical research on probability concepts.* University of Klagenfurt, Austria.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the quality of learning: The SOLO taxonomy.* New York: Academic Press.

Biggs, J. B., & Collis, K. F. (1991). Multimodal learning and the quality of intelligent behaviour. In H. A. H. Rowe (Ed.), *Intelligence: Reconceptualisation and measurement* (pp. 57-76). Hillsdale, NJ: Lawrence Erlbaum.

Brandt, R. (1992). On performance assessment: A conversation with Grant Wiggins. *Educational Leadership, 49*(8), 35-37.

Bransford, J., Hasselbring, T., Barron, B., Kulewicz, S., Littlefield, J., & Goin, L. (1989). Uses of macro-contexts to facilitate mathematical thinking. In R. I. Charles, & E. A. Silver (Eds.), *The teaching and assessing of mathematical problem solving* (pp. 125-147). Reston, VA: National Council of Teachers of Mathematics.

Bransford, J., & Vye, N. (1989). A perspective on cognitive research and its implications in instruction. In L. B. Resnick, & L. E. Klopfer (Eds.), *Toward the thinking curriculum: Current cognitive research* (1989 Yearbook of the Association for Supervision and Curriculum Development). Alexandria, VA: ASCD.

BRIGHT, G. W., & Friel, S. N. (in press). Graphical representations: Helping students interpret data. To appear in S. P. Lajoie (Ed.), *Reflections on statistics: Agendas for learning, teaching, and assessment in K-12.* Hillsdale, NJ: Lawrence Erlbaum.

BRIGHT, G., & Hoeffner, K. (1993). Measurement, probability, statistics, and graphing. In D. T. Owens (Ed.), *Research ideas for the classroom: Middle grades mathematics* (pp. 78-98). New York: Macmillan Publishing Co.

Carnevale, A. P., Gainer, L. J., & Meltzer, A. S. (1990). *Workplace basics: The essential skills employers want.* San Francisco: Jossey-Bass.

Carpenter, T., & Lehrer, R. (in preparation). Learning mathematics with understanding. In E. Fennema & T. Romberg (Eds.), *Classrooms that promote understanding.*

Case, R. (1985). *Intellectual development: Birth to adulthood.* New York: Academic Press.

Castles, I. (1992). *Surviving statistics: A user's guide to the basics.* Canberra: Australian Bureau of Statistics.

CHANCE, B. (1997). Experiences with authentic assessment techniques in an introductory statistics course. *Journal of Statistics Education* [Online], *5*(3).

Charles, R., Lester, F., & O'Daffer, P. (1987). *How to evaluate progress in problem solving.* Reston, VA: National Council of Teachers of Mathematics.

Chatterjee, S., Handcock, M. S., & Simonoff, J. S. (1995*). A casebook to accompany a first course in data analysis.* New York: Wiley.

CICCHITELLI, G., Bartolucci, F., & Forcina, A. (1999, August). Assessment in statistics using the personal computer. Paper presented at the *Fifty-second International Statistical Institute Session*, Helsinki, Finland.

CLARK, M. (1994). The effect of context on the teaching of statistics at first year university level. In L. Brunelli, & G. CICCHITELLI (Eds.), *IASE, Proceedings of the First Scientific Meeting* (pp. 105-113). Perugia, Italy: University of Perugia.

Clayden, A. D., & Croft, M. R. (1989). Statistical consultation - Who's the expert? Paper presented at the *AI and Statistics Conference*, Fort Lauderdale, Florida.

COBB, G. W. (1992) Teaching statistics. In L. Steen (Ed.), *Heeding the call for change: Suggestions for curricular action.* Washington, DC: The Mathematical Association of America.

COBB, G. W. (1998, April). The objective-format question in statistics: Dead horse, old bath water, or overlooked baby*?* Paper presented at the *Annual Meeting of the American Educational Research Association*, San Diego, CA.

Cockcroft, W. (chair) (1982). *Mathematics counts.* London: Her Majesty's Stationery Office.

Cohen, S., Chechile, R., Smith, G., Tsai, F., & Burns, G. (1994). A method for evaluating the effectiveness of educational software. *Behavior Research Methods, Instruments & Computers. 26* (2)*,* 236-241.

Cohen, S., Smith, G. E., Chechile, R. A., Burns, G., & Tsai, F. (1996) Impediments to learning probability and statistics identified from an evaluation of instructional software. *Journal of Educational and Behavioral Statistics. 21* (1), 35-54.

Cohen, S., Smith, G., Chechile, R., & Cook, R,. (1994) Designing software for conceptualizing statistics. In L. Brunelli & G. CICCHITELLI (Eds.), *IASE: Proceedings of the First Scientific Meeting* (pp. 237-245). Perugia, Italy: University of Perugia.

College Board (1998*). Advanced placement course description.* Princeton, NJ: College Entrance Examination Board and Educational Testing Service.

Collins, A., Brown, J. S., & Newman, S. E. (1989). Cognitive apprenticeship: Teaching the craft of reading, writing, and mathematics. In L. Resnick (Ed.), *Knowing, learning, and instruction: Essays in honor of Robert Glaser* (pp. 453-494). Hillsdale, NJ: Lawrence Erlbaum.

Colvin, S., & Vos, K. (1997). Authentic assessment models for statistics education. In I. Gal, & J. B. GARFIELD (Eds*.), The assessment challenge in statistics education* (pp. 27-36). Amsterdam: IOS Press.

COMAP, 1990. *Against all odds: Inside statistics.* A publication of the Consortium for Mathematics and Its applications. New York: W. H. Freeman.

Cooper, W., & Davies, J. (Eds.) (1990 to present). *Portfolio Assessment Clearinghouse Newsletter.* (Available from San Dieguito Union High School district, 710 Encinitas Blvd., Encinitas, CA 92024, 619-753-6491).

Cross, K. P., & Steadman, M. H. (1996*). Classroom research: Implementing the scholarship of teaching.* San Francisco: Jossey-Bass.

Curcio, F. R. (1981). *The effect of prior knowledge, reading and mathematics achievement, and sex on comprehending mathematical relationships expressed in graphs.* (Final report to the National Institute of Education). Brooklyn, NY: St. Francis College. (ERIC Document Reproduction Service No. ED 210 185)

Curcio, F. R. (1987). Comprehension of mathematical relationships expressed in graphs. *Journal for Research in Mathematics Education, 18,* 382-393.

Curcio, F. R. (1989). *Developing graph comprehension: Elementary and middle school activities.* Reston, VA: National Council of Teachers of Mathematics.

Curcio, F., & Artzt, A. (1997). Assessing students' statistical problem-solving behaviors in a small-group setting. In I. Gal, & J. B. GARFIELD (Eds.*), The assessment challenge in statistics education* (pp. 123-138). Amsterdam: IOS Press.

Curcio, F. R., & Artzt, A. F. (in review). Students communicating in small groups: Making sense of data in graphical form. In M. Bartolini-Bussi, A. Sierpinska, & H. Steinbring (Eds.), *Language and communication in the mathematics classroom.*

Dallal, G. E. (1990). Statistical computing packages: Dare we abandon their teaching to others? *The American Statistician, 44*(4), 39-42.

Dauphinee, T. L., SCHAU, C., & Stevens, J. J. (in press). Survey of attitudes toward statistics: Factor structure and factorial invariance for females and males. *Structural Equation Modeling.*

Davis, R. B., Maher, C. A., & Noddings, N. (1990). Constructivist views of the teaching and learning of mathematics. *Journal for Research in Mathematics Education,* Monograph 4. Reston, VA: National Council of Teachers of Mathematics.

Del Vecchio, A. M. (1994). *A psychological model of statistics course completion.* Unpublished doctoral dissertation, University of New Mexico, Albuquerque.

Dossey, J. A., Mullis, I. V. S., & JONES, C. O. (1993). *Can students do mathematical problem solving?* Washington, DC: US Department of Education.

Dubois, J. G. (1984). Une systematique des configurations combinatoires simples [A systematic for simple combinatorial configurations]. *Educational Studies in Mathematics, 15,* 37-57.

Edwards, K. (1990). The interplay of affect and cognition in attitude formation and change. *Journal of Personality and Social Psychology, 59,* 202-216.

Elliott, G. D. & STARKINGS, S. A. (1994). *Project assessment criteria.* London: South Bank University.

ENGEL, A., Varga, T. & Walser, W. (1976). *Hasard ou stratégie?* [Chance or strategy?]. Paris: O.C.D.L.

English, F. (1992). *Deciding what to teach and test.* Newbury Park, CA: Corwin Press.

Facione, N. C., & Facione, P. A. (1994*). Holistic critical thinking scoring rubric.* Millbrae, CA: California Academic Press.

Fischbein, E. (1975). *The intuitive sources of probabilistic thinking in children.* Dordrecht, The Netherlands: Reidel.

Fischbein, E. (1987). *Intuition in science and mathematics.* Dordrecht, The Netherlands: Reidel.

Fischbein, E. & Gazit, A. (1988). The combinatorial solving capacity in children and adolescents. *Zentralblatt für Didaktitk der Mathematik, 5,* 193-198.

Fischbein, E., Pampu, I., & Minzat, I.(1970). Effects of age and instruction on combinatorial ability in children. *The British Journal of Psychology, 40* (3), 261-270.

Fischbein, E., Pampu, I., & Minzat, I. (1975) The child's intuition of probability. Appendix II in Fischbein, E. *The intuitive sources of probabilistic thinking in children.* Dordrecht, The Netherlands: Reidel.

Fong, G. T., Krantz, D. H., & Nisbett, R. E. (1986). The effects of statistical training on thinking about everyday problems. *Cognitive Psychology, 18,* 253-292.

Frid, S. D. (1992). Calculus students' sources of conviction. In B. Southwell, B. Perry, & K. Owens (Eds.), *Space—the first and final frontier. Proceedings of the Fifteenth Annual Conference of the Mathematics Education Research Group of Australasia (MERGA).* (pp. 294-304). Sydney, NSW: MERGA.

Friel, S. N., & BRIGHT, G. (1995). *Assessing students' understanding of graphs: Instruments and instructional module.* Chapel Hill, NC: UNC Mathematics and Science Education Network.

Friel, S., BRIGHT, G., Frierson, D., & KADER, G. (1997). A framework for assessing knowledge and learning in statistics (K-8). In I. Gal, & J. B. GARFIELD (Eds.*), The assessment challenge in statistics education* (pp. 35-63). Amsterdam: IOS Press.

Friel, S. N., & Corwin R. B. (1990). Implementing the Standards: The statistics standards in K-8 mathematics. *Arithmetic Teacher, 38*(2), 35-39.

Friel, S. N., & Joyner, J. (1997). *Teach-Stat for teachers: Professional development manual.* Palo Alto, CA: Dale Seymour Publications.

Friel, S. N., Mokros, J. R., & Russell, S. J. (1992). *Statistics: Middles, means and in-betweens.* Palo Alto, CA: Dale Seymour Publications.

Friel, S. N., Russell, S., & Mokros, J. R. (1990). *Used numbers: Statistics: middles, means, and in-betweens.* Palo Alto, CA: Dale Seymour Publications.

Frith, D. S., & MacIntosh, H. G. (1984). *A teacher's guide to assessment.* Cheltenham, UK: Stanley Thornes Publishers Ltd.

Gal, I. (1993). Reaching out: Some issues and dilemmas in expanding statistics education. In L. PEREIRA-MENDOZA (Ed.), *Introducing data-analysis in the schools: Who should teach it and how?* (pp. 189-203). Voorburg, The Netherlands: International Statistics Institute.

Gal, I. (1994). Assessment of interpretive skills. Summary of Working Group at the *Conference on Assessment Issues in Statistics Education*, Philadelphia, Pennsylvania, September, 1994.

Gal, I. (1995). Statistical tools and statistical literacy: The case of the average. *Teaching Statistics, 17*(3), 97-99.

Gal, I. (in press). Statistical literacy: Conceptual and instructional issues. To appear in: J. O'Donoghue, D. Coben, & G. Fitzsimons (Eds.), *Issues in adult numeracy education.* London: Kluwer.

Gal, I. (in press). Assessing statistical knowledge as it relates to students' interpretation of data. In S. Lajoie (Ed.), *Reflections on statistics: Agendas for learning, teaching, and assessment in school contexts.* Hillsdale, NJ: Lawrence Erlbaum.

Gal, I., & Baron, J. (1996). Understanding repeated simple choices. *Thinking and Reasoning,* 2(1), 1-18.

Gal, I., & GARFIELD, J. (Eds.) (1997*). The assessment challenge in statistics education.* Amsterdam: IOS Press.

Gal, I., & Ginsburg, L. (1994). The role of beliefs and attitudes in learning statistics: Toward an assessment framework. *Journal of Statistics Education* [Online], *2* (2).

Galbraith, P (1993). Paradigms, problems and assessment: some ideological implications. In M. Niss (Ed.), *Investigations into assessment in mathematics education: An ICMI study* (pp. 73–86). Dordrecht, The Netherlands: Kluwer.

GARFIELD, J. B. (1991). Evaluating students understanding of statistics: Developing the Statistical Reasoning Assessment. In R. G. Underhill (Ed.), *Proceedings of the Thirteenth annual meeting of the Psychology of Mathematics Education Group.* Vol. 2.

GARFIELD, J. B. (1993). An authentic assessment of students' statistical knowledge. In N. L. Webb & A. F. Coxford (Eds.), *Assessment in the mathematics classroom* (pp. 187-196). Reston, VA: National Council of Teachers of Mathematics.

GARFIELD, J. (1994). Beyond testing and grading: using assessment to improve students' learning. *Journal of Statistics Education* [Online], *2*(1).

GARFIELD, J. (1995a). How students learn statistics. *International Statistical Review. 63*(1), 25-34.

GARFIELD, J. (1995b). Key ideas of randomness and uncertainty. Keynote speech at *SciMath writing conference.* Chaska, MN.

GARFIELD, J. (1996). Assessing student learning in the context of evaluating a Chance Course. *Communications in Statistics: Theory and Methods, 25*(11), 2863-2873.

GARFIELD, J. (1998, April*).* Challenges in assessing statistical reasoning. Paper presented at the annual meeting of the *American Educational Research Association*, San Diego, CA.

GARFIELD, J., & Ahlgren, A. (1988). Difficulties in learning basic concepts in probability and statistics: Implications for research. *Journal for Research in Mathematics Education, 19*, 44-63.

GARFIELD, J., delMas, R., & CHANCE, B. (1999a, January*).* Using technology to improve statistical reasoning. Paper presented at the *Annual Joint Mathematics Meetings*, San Antonio, TX.

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GARFIELD, J., delMas, R., & CHANCE, B. (1999b, April). The role of assessment in research on teaching and learning statistics. Paper presented at the *Annual Meeting of the American Educational Research Association,* Montreal, Canada.

GARFIELD, J., & Gal, I. (1999). Assessment and statistics education: Current challenges and directions. *International Statistical Review, 67*, 1-12.

Garofalo, J., & Lester, F. K. Jr. (1985). Metacognition, cognitive monitoring, and mathematical performance. *Journal for Research in Mathematics Education, 16*, 163-176.

Gelman, A., Nolan, D., Men, A., Warmerdam, S., & Bautista, M. (1998). Student projects on statistical literacy and the Media. *The American Statistician, 52*(2), 160-166.

Gigerenzer, G., Swijtink, Z., Daston, L., Beatty, J., & Kruger, L. (1989). *The empire of chance: How probability changed science and everyday life.* Cambridge, UK: Cambridge University Press.

Goodlad, J. (1984). *A place called school.* New York: McGraw Hill.

Graham, A. (1987). *Statistical investigations in the secondary school.* Cambridge, UK: Cambridge University Press.

Graham, A. (1990). Statistical investigations—data handling to a purpose. *Teaching Statistics, 12*(2), 58-60.

Gravemeijer, K. (1994). Educational development and developmental research in mathematics education. *Journal for Research in Mathematics Education, 25*, 443-471.

GREEN, D. R. (1981). *Probability concepts in school pupils aged 11-16 years.* Unpublished dissertation. Loughborough University, England.

GREEN, D. R. (1983). A survey of probability concepts in 3000 students aged 11-16 years. In D. R. Grey, P. Holmes, V. Barnett, & G. M. Constable (Eds.), *Proceedings of the First International Conference on Teaching Statistics* (pp. 766-783). Sheffield, UK: Teaching Statistics Trust.

Green, K. E. (1993, April). Affective, evaluative, and behavioral components of attitudes toward statistics. Paper presented at the *Annual Meeting of the American Educational Research Association*, Atlanta, GA.

Green, K. E. (1994, April). The affective component of attitude in statistics instruction. Paper presented at the *Annual Meeting of the American Educational Research Association*, New Orleans, LA.

Greer, B., & Semrau, G. (1984). Investigating psychology students' conceptual problems in relation to learning statistics. *Bulletin of the British Psychological Society, 37*, 123-5.

Grimaldi, R. (1989). *Discrete and combinatorial mathematics. An applied introduction.* Reading, MA: Addison-Wesley.

Gronlund, N. E. (1993). *How to make achievement tests and assessments* (5th Edition). New York: Allyn and Bacon.

Guthrie, J. T., Weber, S., & Kimberly, N. (1993). Searching Documents: Cognitive processes and deficits in understanding graphs, tables, and illustrations. *Contemporary Educational Psychology, 18*, 186-221.

Hacking, I. (1990). *The taming of chance.* Cambridge, UK: Cambridge University Press.

Hancock, C., Kaput, J. J., & Goldsmith, L. T. (1992). Authentic inquiry with data: Critical barriers to classroom implementation. *Educational Psychologist, 27*, 337-364.

HARNISCH, D. L., Sato, T., Zheng, P., Yamagi, S., & Connell, M. (1994, April). Concept mapping approach and its applications in instruction and assessment. Paper presented at the *Meeting of the American Educational Research Association,* New Orleans, LA.

Hart, E. W. (1992). Discrete mathematics: An exciting and necessary addition to the secondary school curriculum. In M. J. Kenney and C. R. Hirsch (Eds.), *Discrete mathematics across the curriculum, K-12* (pp. 67-77), Reston, VA: National Council of Teachers of Mathematics.

HAWKINS, A. (1996). Myth-Conceptions. In J. B. GARFIELD, & G. BURRILL (Eds*.), Research on the role of technology in teaching and learning statistics: Proceedings of the 1996 IAE Round Table Conference.* Voorburg, The Netherlands: International Statistical Institute.

HAWKINS, A., JOLLIFFE, F., & Glickman, L. (1992). *Teaching statistical concepts.* London: Longman.

HAWKINS, A. S., & Kapadia, R. (1984). Children's conceptions of probability: A psychological and pedagogical review. *Educational Studies in Mathematics*, 15, 349-377.

Heitele, D. (1975). An epistemological view on fundamental stochastic ideas. *Educational Studies in Mathematics, 6,* 187-205.

Helgeson, S. L. (1993). *Assessment of science teaching and learning outcomes.* Monograph #6, March 1993. National Center for Science Teaching and Learning, Ohio State University.

Herman, J. L., Aschbacher, P. R., & Winters, L. (1992). *A practical guide to alternative assessment.* Alexandria, VA: Association for Supervision and Curriculum Development.

Hibbard, M. (1992). Bringing authentic performance assessment to life with cooperative learning. *Cooperative Learning, 13,* 30-32.

Hill, N., & Walsh, S. (1997). Summer is here, and statistics means sunflowers*! Mathematics Teaching, 161,* 42-43.

Hillyer, J. (1979). Statistics at CEE. *Teaching Statistics 1*(2), 56-59.

Holley, C. D., & Dansereau, D. F. (1984). *Spatial learning strategies: Techniques, applications, and related issues.* Orlando: Academic Press.

Horton, P. B., McConney, A. A., Gallo, M., Woods, A. L., Senn, G. J., & Hamelin, D. (1993). An investigation of the effectiveness of concept mapping as an instructional tool. *Science Education, 77,* 95-111.

Hubbard, R. (1997). Assessment and the process of learning statistics*. Journal of Statistics Education* [Online], *5*(1).

Inhelder, B. & Piaget, J. (1955). *De la logique de l'enfant à la logique de l'adolescent.* [From the logic of child to the logic of adolescent]. Paris: Presses Universitaires de France.

Inspiration [Computer software]. (1994). Portland, OR: Inspiration Software, Inc.

Johnson, D. W., JOHNSON, R. T., & Smith, K. A. (1991). *Active learning: Cooperation in the college classroom.* Edina, MN: Interaction Book.

Johnson, P. J., Goldsmith, T. E., & Teague, K. W. (1995). Similarity, structure, and knowledge: A representational approach to assessment. In P. D. Nichols, S. F. Chipman, & R. L. Brennan (Eds.), *Cognitively diagnostic assessment* (pp. 221-249). Hillsdale, NJ: Lawrence Erlbaum.

JOLLIFFE, F. (1991). New approaches to statistics. In S. McAllister, & M. Speller (Eds.) *Proceedings, Mathematics in a changing culture Conference*, (pp. 1-8). Glasgow College, UK.

JOLLIFFE, F. (1993). The preliminary stages of data analysis at the school level. In Introducing data analysis in the schools: who should teach it and how? In L. PEREIRA-MENDOZA (Ed.), *Introducing data-analysis in the schools: Who should teach it and how?* (pp. 87-96). Voorburg, The Netherlands: International Statistics Institute.

Jonassen, D. H., Beissner, K., & Yacci, M. (1993). *Structural knowledge: Techniques for representing, conveying, and acquiring structural knowledge.* Hillsdale, NJ: Lawrence Erlbaum.

JONES, G., Langrall, C., Thornton, C., & Mogill, A. (1997). A framework for assessing and nurturing young children's thinking in probability. *Educational Studies in Mathematics, 32,* 101-125.

KADER, G. (1992). Implementing the NCTM Standards in probability and statistics in grades 9-12: Project STAT-LINC. Paper presented at the *1992 Winter Meeting of the American Statistical Association*, Louisville, KT.

KADER, G. & Perry, M. (1994). Learning statistics. *Mathematics teaching in the middle school, 1*(2), 130 - 136.

Kahneman, D. (1991). Judgment and decision making: A personal view. *Psychological Science*, 2(3), 142-145.

Kahneman, D. Slovic, P., & Tversky, A. (1982). *Judgement under uncertainty: Heuristics and biases.* Cambridge, UK: Cambridge University Press.

Kahneman, D., & Tversky, A. (1982). Variants of uncertainty. *Cognition, 11,* 143-157.

Kapur, J. N. (1970). Combinatorial analysis and school mathematics. *Educational Studies in Mathematics, 3,* 111-127.

Kaput, J. J. (1992). Technology and mathematics education. In D. A. Grouws (Ed.), *Handbook for research on mathematics teaching and learning* (pp. 515-556). New York: Macmillan.

Keeler, C. (1997). Portfolio assessment in graduate level statistics courses. In I. Gal, & J. B. GARFIELD (Eds.), *The assessment challenge in statistics education* (pp. 165-178). Amsterdam: IOS Press.

Kelly, A.V. (1978). *Mixed-ability grouping: Theory and practice.* London: Harper & Row.

Kimmel, M. L. (1992). Learning from industry: Using quality control techniques to monitor and motivate student progress. *The Statistics Teacher Network, 31,* 1-4.

Knight, P. (1992). How I use portfolios in mathematics. *Educational Leadership, 49*(8), 71-72.

Konold, C. (1987). Teaching probability through modeling real life problems. *The Mathematics Teacher, 80,* 232-235.

Konold, C. (1990). *ChancePlus: A computer based curriculum for probability and statistics.* Annual report to NSF. Scientific Reasoning Research Institute, University of Massachusetts, Amherst.

Konold, C. (1991a). Informal conceptions of probability. *Cognition and Instruction,* 6 (1), 59-98.

Konold, C. (1991b). Understanding students' beliefs about probability. In E. von Glaserfeld (Ed.), *Radical constructivism in mathematics education* (pp. 139-156). Dordrecht, Netherlands: Kluwer.

Konold, C. (1995). Issues in assessing conceptual understanding in probability and statistics. *Journal of Statistics Education* [Online], *3*(1).

Konold, C., Pollatsek, A., Well, A., Lohmeier, J., & Lipson, A. (1993). Inconsistencies in students' reasoning about probability. *Journal for Research in Mathematics Education,* 24 (5), 392-414.

Konold, C., Pollatsek, A., Well, A., & Gagnon, A. (1997). Students analyzing data: Research of critical barriers. In J. B. GARFIELD, & G. BURRILL (Eds*.), Research on the role of technology in teaching and learning statistics: Proceedings of the 1996 IAE Round Table Conference* (pp. 151-167). Voorburg, The Netherlands: International Statistical Institute.

Konold, C., Well, A., Lohmeier, J, & Pollatsek, A. (1993, September*).* Understanding the law of large numbers. Paper presented at the *Fifteenth Annual Conference of the North American Chapter of the International Group for the Psychology of Mathematics Education,* Pacific Grove, CA.

Kroll, D. L., Masingila, J. O., & Mau, S. T. (1992). Grading cooperative problem solving. *Mathematics Teacher, 85,* 619-627.

Lajoie, S. P. (1995). A framework for authentic assessment in mathematics. In T. A. Romberg (Ed.), *Reform in school mathematics and authentic assessment* (pp. 19-37). New York: SUNY Press.

Lajoie, S. P. (in preparation). Understanding of statistics. In E. Fennema & T. Romberg (Eds.), *Classrooms that promote understanding.*

Lajoie, S. P., & Derry, S. J. (Eds.). (1993). *Computers as cognitive tools.* Hillsdale, NJ: Lawrence Erlbaum.

Lajoie, S. P., Jacobs, V. R., & Lavigne, N. C. (1995). Empowering children in the use of statistics. *Journal of Mathematical Behavior, 14* (4), 401-425.

Lajoie, S. P., & Lesgold, A. (1992). Dynamic assessment of proficiency for solving procedural knowledge tasks. *Educational Psychologist, 27* (3), 365-384.

LANDWEHR, J. M., Swift, J., & Watkins, A. E. (1987). *Exploring surveys and information from samples.* Palo Alto, CA: Dale Seymour Pub.

LANDWEHR, J. M., & Watkins, A. E. (1987). *Exploring data.* Palo Alto, CA: Dale Seymour publications.

Lane, S. (1993). The conceptual framework for the development of a mathematics performance assessment instrument. *Educational Measurement: Issues and Practice, 12*(2), 16-23.

Lappan, G., Fey J., Fitzgerald W., Friel S., & PHILLIPS E. (1996). *Data about us.* (Connected Mathematics Project). Palo Alto, CA: Dale Seymour Publications.

Lavigne, N. C. (1994). *Authentic assessment: A library of exemplars for enhancing statistics performance.* Unpublished Master's Thesis. McGill University, Montreal, Quebec, Canada.

Lavigne, N. C., & Lajoie, S. P. (1996). Communicating performance standards to students through technology. *The Mathematics Teacher, 89* (1), 66-69.

LECOUTRE, M. P. (1992). Cognitive models and problem spaces in "purely random" situations. *Educational Studies in Mathematics, 23,* 557-568.

Leder, G. (1992). Assessment: as we sow we reap. In M. Stephens & J. Izard, (Eds.), *Reshaping assessment practices: Assessment in the mathematical sciences under challenge* (pp. 114–124). Hawthorn, Victoria: Australian Council for Educational Research. (Proceedings from the First National Conference on Assessment in the Mathematical Sciences, Geelong, November 1991).

Lehrer, R., & Romberg, T. (1996). Exploring children's data modeling. *Cognition and Instruction, 14*(1), 69-108.

Lesh, R., Amit, M., & Schorr, R. (1997). Using "real-life" problems to prompt students to construct conceptual models for statistical reasoning. In I. Gal & J. B. GARFIELD (Eds.), *The assessment challenge in statistics education.* (pp. 65-83). Amsterdam: IOS Press.

Lesh, R., Hoover, M., & Kelly, A.E. (1992). Equity, assessment, and thinking mathematically: principles for the design of model-eliciting activities. In I. Wirszup & R. Streit (Eds.), *Proceedings of the UCSMP International Conference on Mathematics Education: Developments in school mathematics education around the world: Volume 3* (pp. 104-129). Reston, VA: National Council of Teachers of Mathematics.

Lesh, R., & Lamon, S. J. (1992) (Eds.) *Assessment of authentic performance in school mathematics.* Washington, DC: American Association for the Advancement of Science.

Lindquist, M. M. (Ed.). (1989*). Results from the Fourth Mathematics Assessment of the National Assessment of Educational Progress.* Reston, VA: National Council of Teachers of Mathematics.

Linn, R. L., Baker, E. L., & Dunbar, S. B. (1991). Complex, performance-based assessment: Expectations and validation criteria. *Educational Researcher, 20* (8), 15-21.

Liu, H. J. (1998*). A cross-cultural study of sex differences in statistical reasoning for college students in Taiwan and the United States.* Unpublished doctoral dissertation, University of Minnesota, Minneapolis.

Lovie, P. (1978). Teaching intuitive statistics II: Aiding the estimation of standard deviations. *International Journal of Mathematical Education in Science and Technology, 9,* 213-219.

Lovie, P., & Lovie, A. D. (1976). Teaching intuitive statistics I: Estimating means and variances. *International Journal of Mathematical Education in Science and Technology, 7,* 29-40.

Macdonald-Ross, M. (1977). How numbers are shown. *AV Communication Review, 25,* 359-409.

Mackisack, M. (1994). What is the use of experiments conducted by statistics students*? Journal of Statistics Education* [Online], *2*(1).

Margolin, B. H. (1988). Statistical aspects of using biologic markers. *Statistical Science, 3,* 351-357.

Marshall, S. (1995). *Schemas in problem solving.* Cambridge, UK: Cambridge University Press.

Mastromatteo, M. (1993). Assessment of statistical analysis in eighth grade. In N. Webb (Ed.), *Assessment in the mathematics classroom* (1993 Yearbook of the National Council of Teachers of Mathematics) (pp. 159-66). Reston, VA: National Council of Teachers of Mathematics.

Mathematical Sciences Education Board (1993). *Measuring up: Prototypes for mathematics assessment.* Washington, DC: National Academy Press.

Mathematical Sciences Education Board (MSEB) (1993). *Measuring what counts: A policy brief.* Washington, DC: National Academy Press.

MacGregor, M. (1993). Mathematical report writing—what value? *Australian Mathematics Teacher, 49*(1), 31.

McKnight, C. C. (1990). Critical evaluation of quantitative arguments. In G. Kulm (Ed.), *Assessing higher order thinking in mathematics* (pp. 169-185). Washington, DC: American Association for the Advancement of Science.

McLeod, D. B. (1992). Research on affect in mathematics education: A reconceptualization. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning.* (pp. 575-596). NEW YORK: Macmillan.

Meece, J. L., Wigfield, A., & Eccles, J. S. (1990). Predictors of math anxiety and its influence on young adolescents' course enrolment intentions and performance in mathematics. *Journal of Educational Psychology, 82*, 60-70.

Metz, K. (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.

Millar, M. G., & Millar, K. U. (1990). Attitude change as a function of attitude type and argument type. *Journal of Personality and Social Psychology, 59*, 217-228.

Miller, E. (1992). Tips on assessment and evaluation for cooperative work. *Cooperative Learning, 13*, 48-49.

Montgomery, H., & Allwood, C. M. (1978a). On the subjective representation of statistical problems. *Scandinavian Journal of Educational Research, 22*, 102-127.

Montgomery, H., & Allwood, C. M. (1978b). Subjective confidence in the correctness of statistical problem solutions. *Goteborg Psychological Reports, 8*(1).

MOORE, D. S. (1990). Uncertainty. In L. A. Steen (Ed.), *On the shoulders of giants: New approaches to numeracy* (pp. 95-137). Washington, DC: National Academy Press.

MOORE, D. S.(1992). Teaching statistics as a respectable subject. In F. & S. Gordon (Eds.), *Statistics for the twenty-first Century.* (pp. 14-25). Washington, DC: The Mathematical Association of America.

MOORE, D. (1997). New pedagogy and new content: The case of statistics. *International Statistical Review, 65*(2), 123-137.

Morris, C. (1989). *Quantitative approaches in business studies, 2nd edition.* London: Pitman Publishers.

National Council of Teachers of Mathematics. (1989). *Curriculum and evaluation standards for school mathematics.* Reston, VA: Author.

National Council of Teachers of Mathematics. (1991). *Professional standards for teaching mathematics. Reston,* VA: Author.

National Council of Teachers of Mathematics. (1995). *Assessment standards for school mathematics.* Reston, VA: Author.

Naveh-Benjamin, M., Lin, Y., & McKeachie, W. J. (1995). Inferring students' cognitive structures and their development using the "Fill-in-the-Structure" (FITS) technique. In P. D. Nichols, S. F. Chipman, & R. L. Brennan (Eds.), *Cognitively diagnostic assessment* (pp. 279-304). Hillsdale, NJ: Lawrence Erlbaum.

New Zealand. Ministry of Education. (1992). *The New Zealand curriculum framework.* Wellington: Ministry of Education.

New Zealand. Ministry of Education. (1993). *Mathematics in the New Zealand curriculum.* Wellington: Ministry of Education.

Nickerson, R. S. (1995). Can technology help teach for understanding? In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), *Software goes to school: Teaching for understanding with new technologies* (pp. 7-22). NEW YORK: Oxford University Press.

Nisbett, R.E., Krantz, D. H., Jepson, C., & Kunda, Z. (1983). The use of statistical heuristics in everyday inductive reasoning. *Psychological Review. 90* (4), 339-363.

Nitko, A. J., & Lane, S. (1991). Solving problems is not enough: Assessing and diagnosing the ways in which students organise statistical concepts. In D. VERE-JONES (Ed.), *Proceedings of the Third International Conference on Teaching Statistics, Volume 1: School and General Issues* (pp. 467-474). Voorburg, The Netherlands: International Statistical Institute.

Northern Examinations and Assessment Board (1994). *Information technology syllabus.* Manchester, England: Author.

Novak, J. D., & Gowin, D. B. (1984). *Learning how to learn.* New York: Cambridge University Press.

Novak, J. D., & Musonda, D. (1991). A twelve year longitudinal study of science concept learning. *American Educational Research Journal, 28,* 117-153.

Núñez, R. (1993). Approaching infinity: A view from cognitive psychology. *Proceedings of the Fifteenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education., Volume 1,* 105-111.

Ohio Math Project (1992). *Introduction to algebra and statistics.* Dayton, OH: EPA Associates.

Olsen, C. (1998, *August). What's a rubric? Scoring the open-ended questions.* Paper presented at the Joint Statistical Meetings, Dallas, TX.

Pandey, T. (1990). Power items and the alignment of curriculum and assessment. In G. Kulm (Ed.), *Assessing higher order thinking in mathematics* (pp. 39-51). Washington, DC: American Association for the Advancement of Science.

Paulu, N. (1994). *Improving math and science assessment: Report on the Secretary's third conference on mathematics and science education.* Washington, DC: US Department of Education.

PECK, R., Haugh, L. D., & Goodman, A. (Eds.). (1998*). Statistical case studies: A collaboration between academe and industry.* Philadelphia: American Statistical Association/Society of Industrial and Applied Mathematics.

PEREIRA-MENDOZA, L. & Mellor, J. (1991). Students' concepts of bar graphs: Some preliminary findings. In D. Vere-JONES (Ed.), *Proceedings of the Third International Conference on Teaching Statistics. Volume 1: School and general issues* (pp. 150-157). Voorburg, The Netherlands: International Statistical Institute.

Perkins, D. N., Crismond, D., Simmons, R., & Unger, C. (1995). Inside Understanding. In D. N. Perkins, J. L. Schwartz, M. M. West, & M. S. Wiske (Eds.), *Software goes to school: teaching for understanding with new technologies* (pp. 70-87). New York: Oxford University Press.

Pesci, A. (1994). Tree graphs: visual aids in causal compound experiments. In J. P. da Ponte & J. F. Matos (Eds.). *Proceedings of the Psychology of Mathematics Education Annual Meeting, Volume 4* (pp. 25-32). Lisbon: University of Lisbon.

PHILLIPS, B., & JONES, P., (1991). Developing statistical concepts for engineering students using computer packages. In D. VERE-JONES (Ed.), *Proceedings of the Third International Conference on Teaching Statistics, Volume 2: Teaching statistics beyond school level* (pp. 255-260). Voorburg, The Netherlands: International Statistical Institute.

Piaget, J. (1987). *Possibility and necessity.* Vol. 2: The role of necessity in cognitive development. (Originally published in French in 1983).

Piaget, J., & Inhelder, B. (1951). *La genèse de l'idée d'hasard chez l'enfant.* [The origin of the idea of chance in children]. Paris: Presses Universitaires de France.

Piaget, J., & Inhelder, B. (1975). *The origin of the idea of chance in children.* London: Routledge & Kegan Paul.

Pinker, S. (1990). A theory of graph comprehension. In R. Freedle (Ed.), *Artificial intelligence and the future of testing* (pp. 73-126). Hillsdale, NJ: Lawrence Erlbaum.

Pollatsek, A., Lima, S., & Well, A. D. (1981). Concept or computation: Students' understanding of the mean. *Educational Studies in Mathematics, 12,* 191-204.

Polya, G. (1945). *How to solve it.* Garden City, NY: Doubleday.

Popham, W. J. (1990). *Modern measurement: A practitioner's guide.* London: Prentice Hall.

Pretorius, T. B., & Norman, A. M. (1992). Psychometric data on the statistics anxiety scale for a sample of South African students. *Educational and Psychological Measurement, 52,* 933-937.

Pulaski, M. A. (1980). *Understanding Piaget.* New York: Harper & Row.

Rachlin, S. (1992). Hawaii Algebra: A curriculum research and development model. In T. Cooper (Ed.), *From numeracy to algebra: The proceedings of the second mathematics teaching and learning conference,* (pp. 34-49). Brisbane, Australia: QUT Centre for Mathematics and Science Education.

Radke Sharpe, N. (1998, *August). Assessment issues in introductory and advanced statistics courses.* Roundtable paper presented at the Joint Statistical Meetings, Dallas, TX.

Resnick, L. B. (1987). *Education and learning to think.* Washington, DC: National Academy Press.

Resnick, L. B. (1988). Treating mathematics as an ill-structured discipline. In R. Charles & E. Silver (Eds.), *The teaching and assessing of mathematical problem solving: Multiple research perspectives,* (pp. 32-60). Reston, VA: National Council of Teachers of Mathematics.

Resnick, L. B. & Klopfer, L. E. (1989). Toward the thinking curriculum: An overview. In L. B. Resnick & L. E. Klopfer (Eds.), *Toward the thinking curriculum: Current cognitive research* (1989 Yearbook of the Association for Supervision and Curriculum Development). Alexandria, VA: ASCD.

Roberts, D. M., & Reese, C. M. (1987). A comparison of two scales measuring attitudes towards statistics. *Educational and Psychological Measurement, 47,* 759-764.

Roberts, D. M., & Saxe, J. E. (1982). Validity of a statistics attitude survey: A follow-up study. *Educational and Psychological Measurement, 42,* 907-912.

Romberg, T. (1989). Evaluation: A coat of many colors. In D. Robitaille (Ed.), *Evaluation and assessment in mathematics education* (pp. 3-17). Paris: UNESCO.

Romberg, T. A. (1993). How one comes to know: Models and theories of the learning of mathematics. In M. Niss (Ed.,) *Investigations into assessment in mathematics education: An ICMI study* (pp. 97–111). Dordrecht, The Netherlands: Kluwer.

Romberg, T. A. Allison, J., Clarke, B., Clarke, D., & Spence, M. (Nov., 1991). *School mathematics expectations: A comparison of curricular documents of eight countries with the NCTM Standards of the US* Paper prepared for the New Standards Project.

Romberg, T. A., Zarinnia, E. A., & Collis, K. F. (1991). A new world view of assessment in mathematics. In G. Kulm (Ed.), *Assessing higher order thinking in mathematics* (pp. 21-38). Washington: American Association for the Advancements of Sciences.

Rosebery, A. S., & Rubin, A. (1989). Reasoning under uncertainty: Developing statistical reasoning. *Journal of Mathematical Behavior, 8,* 205-219.

Rubin, A., Bruce, B., & Tenney, Y. (1991). Learning about sampling: Trouble at the core of statistics. In D. Vere-JONES (Ed.), *Proceedings of the Third International Conference on Teaching Statistics. Volume 1: School and general issues* (pp. 314-319). Voorburg: International Statistical Institute.

Rubin, A., & Rosebery, A. (1990). Teacher's misunderstandings in statistical reasoning: Evidence from a field test of innovative materials. In A. HAWKINS (Ed.), *Training teachers to teach statistics.* Voorburg, The Netherlands: International Statistical Institute.

Rubin, A., Rosebery, A. S., & Bruce, B. (1988). *ELASTIC and reasoning under uncertainty: Final report.* Cambridge, MA: Bolt Beranek & Newman.

Ruiz-Primo, M. A., & Shavelso, R. J. (1996). Problems and issues in the use of concept maps in science assessment. *Journal of Research in Science Teaching, 33,* 569-600.

Russell, S. J., & Corwin, R. (1989a). *Used numbers: Real data in the classroom.* Palo Alto, CA: Dale Seymour Publications.

Russell, S. J. & Corwin, R. (1989b). *Statistics: The shape of the data.* Palo Alto, CA: Dale Seymour Publications.

Salomon, G., Perkins, D. N., & Globerson, T. (1991). Partners in cognition: Extending human intelligence with intelligent technologies. *Educational Researcher, 20,* 10-16.

SCANS (1992). *Learning a living: A blueprint for high performance.* Secretary's Commission on Achieving Necessary Skills, US Department of Labor. Washington, DC: US Government Printing Office.

SCHAU, C., Dauphinee, T., & Del Vecchio, A. (1992, April). The development of the Survey of Attitudes Toward Statistics. Paper presented at the *Annual Meeting of the American Educational Research Association,* San Francisco, CA.

SCHAU, C., & Mattern, N. (1997). Assessing students' connected understanding of statistical relationships. In I. Gal & J. B. GARFIELD (Eds*.), The assessment challenge in statistics education* (pp. 91-104). Amsterdam: IOS Press.

SCHAU, C., Stevens, J., Dauphinee, T. L., & Del Vecchio, A. (1995). The development and validation of the survey of attitudes toward statistics. *Educational and Psychological Measurement,* 55, 868-875.

SCHEAFFER, R. L. (1988). Statistics in the schools: The past, present and future of the quantitative literacy project. *Proceedings of the American Statistical Association from the Section on Statistical Education* (pp. 71-78). Washington, DC: American Statistical Association.

SCHEAFFER, R. L. (1999, Spring). Making the grade – again: AP Statistics, 1998. *Stats: The Magazine for Students of Statistics, 25*, 3-5.

Schifter, D. & Fosnot, C. (1992). *Reconstructing mathematics education: Stories of teachers meeting the challenge of reform.* New York: Teachers College Press.

Schifter, D. & Simon, M. (1992). Assessing teachers' development of a constructivist view of mathematics learning. *Teaching & Teacher Education, 8*(2), 187-197.

Schoenfeld. A. H. (1985). *Mathematical problem solving.* Orlando, FL: Academic Press.

Schoenfeld, A. H. (1987). What's all the fuss about metacognition? In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 189-215). Hillsdale, NJ: Lawrence Erlbaum.

Schoenfeld, A. H. (1992). Learning to think mathematically: Problem solving, metacognition, and sense making in mathematics. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 334-370). New York: Macmillan.

Schwartz, J. L. (1989). Intellectual mirrors; A step in the direction of making schools into knowledge-making places. *Harvard Educational Review, 59*(1), 51-61.

SHAUGHNESSY, J. M. (1992). Research on probability and statistics: Reflections and directions. In D.A. Grouws (Ed.) *Handbook of research on mathematics teaching and learning*, (pp. 465-494). New York: Macmillan.

Shavelson, R. J. & Baxter, G. (1992). What we've learned about assessing hands-on science. *Educational Leadership, 49*(8), 20-25.

Silver, E. A. (1987). Foundations of cognitive theory and research for mathematics problem solving instruction. In A. H. Schoenfeld (Ed.), *Cognitive science and mathematics education* (pp. 33-60). Hillsdale, NJ: Lawrence Erlbaum.

Skemp, R. R. (1979). *Intelligence, learning and action.* Chichester, UK: Wiley.

Skemp, R. R. (1987). *The psychology of learning mathematics.* Hillsdale, NJ: Lawrence Erlbaum.

Smith, J. T. & Griffin, M. P. (1991). The use of video feedback in training statistical consultants. In D. Vere-JONES (Ed.), *Proceedings of the Third International Conference on Teaching Statistics, Volume 2* (pp. 461-468). Voorburg, The Netherlands: International Statistical Institute.

Smith, J., diSessa, A., & Roschelle, J. (1993). Misconceptions reconceived: A constructivist analysis of knowledge in transition. *Journal of the Learning Sciences, 3*(2), 115-163.

Sommers, J. (1992). Statistics in the classroom: Written projects portraying real-world situations. *Mathematics Teacher, 85*, 310-313.

STARKINGS, S. (1997). Assessing student projects. In I. Gal & J. B. GARFIELD (Eds.*), The assessment challenge in statistics education* (pp. 139-151). Amsterdam: IOS Press.

Stenmark, J. K. (1989). *Assessment alternatives in mathematics: an overview of assessment techniques that promote learning.* Berkeley CA: EQUALS and the Californian Mathematics Council Campaign for Mathematics.

Stenmark, J. K. (1991). *Mathematics assessment: Myths, models good questions and practical suggestions.* Reston VA: National Council of Teachers of Mathematics.

Stiggins, R. J. (1987). Design and development of performance assessments. *Educational Measurement: Issues and Practice, 6* (3), 33-42.

Stodolsky, S. S. (1985). Telling math: Origins of math aversion and anxiety. *Educational Psychologist, 20* (3), 123-133.

Stone, A., & Russell, S. J. (1992). *Counting ourselves and our family.* Palo Alto, CA: Dale Seymour Publications.

Surber, J. R. (1984). Mapping as a testing and diagnostic device. In C. D. Holley, & D. F. Dansereau (Eds.), *Spatial learning strategies: Techniques, applications, and related issues* (pp. 213-233). Orlando: Academic Press.

Swets, J. A., Rubin, A., & Feurzeig, W. (1987) *Cognition, computers, and statistics: software tools for curriculum design, Report No. 6447*, Cambridge, MA: BBN, Inc.

Tobias, S. (1993). *Overcoming math anxiety.* New York: Norton.

Travers, K., Stout, W., Swift, J., & Sextro, J. (1985). *Using statistics.* Menlo-Park, CA: Addison-Wesley.

Tufte, E. R. (1983). *The visual display of quantitative information.* Chesire, CT: Graphics Press.

Tversky, A. & Kahneman, D. (1971). Belief in the law of small numbers. *Psychological Bulletin, 2,* 105-110.

Tversky, A. & Kahneman, D. (1974). Judgment under uncertainty: Heuristics and b*iase*s. *Science, 185,* 1124-1131.

Vallone, R. & Tversky, A. (1985). The hot hand in basketball: On the misperception of random sequences. *Psychological Review, 90,* 293-315.

Vermont Department of Education (1991). *Looking beyond "the answer": The report of Vermont's mathematics portfolio assessment program.* Montpelier, Vermont.

von Glasersfeld, E. (1987). Learning as a constructive activity. In C. Janvier (Ed.), *Problems of representation in the teaching and learning of mathematics* (pp. 3-17). Hillsdale, NJ: Lawrence Erlbaum.

von Glasersfeld, E. (1989). Constructivism in education. In T. Husén, T. N. Postlewaite (Eds.), *The international encyclopaedia of education: Research and studies.* Supplementary Volume (pp. 162–163). New York: Pergamon Press.

Wainer, H. (1980). A test of graphicacy in children. *Educational Researcher. 21*(1), 14-23.

Walklin, L. (1991). *Instructional Techniques & Practice.* Cheltenham, UK: Stanley Thornes Publishers Ltd.

Wallman, K. K. (1993). Enhancing statistical literacy: Enriching our society. *Journal of the American Statistical Association, 88,* 1-8.

Waters, L. K., Martelli, A., Zakrajsek, T., & Popovich, P. M. (1988). Attitudes toward statistics: An evaluation of multiple measures. *Educational and Psychological Measurement, 48,* 513-516.

WATSON, J. M. (1992). Fishy statistics. *Teaching Statistics, 14* (3), 17-21.

WATSON, J. M. (1993). Introducing the language of probability through the media. In M. Stephens, A. Waywood, D. CLARKE, & J. Izard (Eds.), *Communicating mathematics – Perspectives from current research and classroom practice in Australia* (pp. 119-139). Melbourne: Australian Council for Educational Research.

WATSON, J. (1997). Assessing statistical thinking using the media. In I. Gal & J. B. GARFIELD (Eds*.), The assessment challenge in statistics education* (pp. 107-121). Amsterdam: IOS Press.

WATSON, J. M., Collis, K. F., Callingham, R. A., & Moritz, J. B. (In press). A model for assessing higher order thinking in Statistics. *Educational Research and Evaluation.*

Webb, N. L. (1992). Assessment of students' knowledge of mathematics: Steps toward a theory. In D. A. Grouws (Ed.), *Handbook of research on mathematics teaching and learning* (pp. 661-683). New York: Macmillan.

Webb, N. L. (1993). Assessment for the mathematics classroom. In N. L. Webb, & A. F. Coxford (Eds.), *Assessment in the Mathematics Classroom, 1993 Yearbook* (pp. 1-6). Reston, VA: National Council of Teachers of Mathematics.

Webb, R., O'Meara, M, & Brown, B. (1993, January 28). Coles Myer accelerates retail purge. *Australian Financial Review*, p. 1.

WILD, C. J. (1994). Embracing the "wider view" of statistics. *The American Statistician, 48,* 163-171.

WILD, C. J. (1995). Continuous improvement of teaching: A case study in a large statistics course. *International Statistical Review, 63,* 49-68.

WILD, C. J., Triggs, C. M., & Pfannkuch, M. (1994). Assessment on a budget: Using traditional methods imaginatively. Technical Report STAT9411 (Revised 1995), Department of Statistics, University of Auckland.

Wiliam, D. (1994). Assessing authentic tasks: alternatives to mark schemes. *Nordic Studies in Mathematics Education 2*(1), 48–68.

Wise, S. L. (1985). The development and validation of a scale measuring attitudes towards statistics. *Educational and Psychological Measurement, 45*, 401-405.

Woehlke, P. L. (1991, April). An examination of the factor structure of Wise's attitudes toward statistics scale. Paper presented at the A*nnual Meeting of the American Educational Research Association*, Chicago, IL.

Zawojewski, J. & SHAUGHNESSY, J. M. (in press). Data and chance. In E. Silver & P. Kenney (Eds*.), Results from the Seventh Mathematics Assessment of the National Assessment of Educational Progress.* Reston, VA: National Council of Teachers of Mathematics.

Zessoules, R. & Gardner, H. (1991). Authentic assessment: Beyond the buzzword and into the classroom. In V. Perrone (Ed.), *Expanding student assessment.* Alexandria, VA: Association for Supervision and Curriculum Development.

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8. *Mathematical Thinking and Learning* Special Issue

Volume 2, numbers 1 & 2, of the journal *Mathematical Thinking and Learning*, published in May, 2000 is devoted to "Statistical Thinking and Learning". The invited editor, Brian Greer suggests in the introduction that this issue reflects major developments within statistics education during recent years. Statistics has entered the mathematics curriculum in many countries and the papers in the issue reflect current research in this area. They also make clear that the importance of understanding statistics is not confined to school mathematics. Regardless of our position as regards inference, we need to understand the conceptions and misconceptions of students and experimental researchers, in order to improve the education of the former and the use of statistics by the latter. Below we include the summaries of the papers published in this issue.

Jane M. WATSON and Jonathan B. Moritz. *The longitudinal development of understanding of average.* (pp. 11–50). The development of the understanding of average was explored through interviews with 94 students from Grades 3 to 9. follow-up interviews with 22 of these students after 3 years, and follow-up interviews with 21 others after 4 years. Six levels of response were observed based on hierarchical model of cognitive functioning. The first four levels described the development of the concept of average from colloquial ideas into procedural or conceptual descriptions to derive a central measure of a data set. The highest two levels represent transferring this understanding to one or more applications in problem-solving tasks to reverse the averaging process and to evaluate a weighted mean. Usage of ideas associated with the three standard measures of central tendency and with representation are documented as are strategies for problem solving. Implications for mathematics educators are discussed.

Richard Lehrer and Leona Schauble. *Inventing data structures for representational purposes: elementary grade students' classification models.* (pp. 51–74).This study concerns the development of children's understanding of data and classification, Three intact classrooms of students and their teachers (18 at 1st and 2nd grade, 35 at 4th grade, and 22 at 5th grade) worked over several sessions to categorise drawings made by other children and to progressively "mathematize " their categorisation rules. The goal was to develop a model that would make explicit their initial guesses about the grade level of the artists. In small groups, students developed, applied, and made interactions of revisions to their data models. The details of instruction and duration varied somewhat in accord with the capabilities and needs of students of different ages. The youngest children evolved systems of attributes which described their categories in a *post hoc* fashion but failed to come to regard those rules as a model to guide classification. In contrast, 4th and 5th graders considered their category systems as models that logically constrained the members admitted to categories. These students came to appreciate dimensional attribute-value structure, although many continued to include redundant or extraneous information. They incorporated and discussed a variety of kinds of decision rules, including ways of combining information, such as differentially weighing

diagnostic attributes. By engaging with data characterised by prototypic rather than crisp membership values, students had the opportunity to see the intellectual work performed by practices of data modelling.

Carmen BATANERO. Carmen BATANERO. *Controversies around the role of statistical tests in experimental research.* (pp. 75–98). In spite of the widespread use of significance testing in empirical research, its interpretation and researchers' excessive confidence in its results have been criticised for years. In this paper, we first describe the logic of statistical testing in the Fisher and Neyman-Pearson approaches, review some common misinterpretations of basic concepts behind statistical tests, and analyse the philosophical and psychological issues that can contribute to these misinterpretations. We then revisit some frequent criticisms against statistical tests and conclude that most of them refer not to the tests themselves, but to the misuse of tests on the part of researchers. We agree with Levin (1998a) that statistical tests should be transformed into a more intelligent process that helps researchers in their work, and finally suggest possible ways in which statistical education might contribute to the better understanding and application of statistical inference.

Joan GARFIELD and Beth CHANCE. *Assessment in statistics education: Issues and challenges.* (pp. 99–126). There have been many changes in educational assessment in recent years, both within the fields of measurement and evaluation and in specific disciplines. In this article we summarise current assessment practices in statistics education, distinguishing between assessment for different purposes and assessment at different educational levels. To provide a context for assessment of statistical learning, we first describe current learning goals for students. We then highlight recent assessment methods being used for different purposes: individual student evaluation, large-scale group evaluation, and as a research tool. Examples of assessment used in teaching statistics in primary schools, secondary schools, and tertiary schools are given. We then focus on 3 examples of effective use of assessment and conclude with a description of some current assessment challenges.

Dani BEN-ZVI. *Toward understanding the role of technological tools in statistical learning* (pp. 127–155). This article begins with some context setting on new views of statistics and statistical education. These views are reflected, in particular, in the introduction of exploratory data analysis (EDA) into the statistics curriculum. Then, a detailed example of EDA learning activity in the middle school is introduced, which makes use of the power of the spreadsheet to mediate students' construction of meanings for statistical conceptions. Through this example, I endeavour to illustrate how an attempt at serious integration of computers in teaching and learning statistics brings about a cascade of changes in curriculum materials, classroom praxis, and students' ways of learning. A theoretical discussion follows that underpins the impact of technological tools on teaching and learning statistics by emphasising how the computer lends itself to supporting cognitive and socio-cultural processes. Subsequently, I present a sample of educational technologies, which represents the sorts of software that have typically been used in statistics instruction: statistical packages (tools); micro-worlds, tutorials, resources (including Internet resources) and teachers' meta-tools. Finally, certain implications and recommendations for the use of computers in the statistical educational milieu are suggested.

9. Other Publications of Interest

Beltrami, E. (1999). *What is random? Chance and order in mathematics and life.* New York: Springer. People familiar with quantum indeterminacy tell us that order is an illusion and that the world is fundamentally random. Yet these same people also say that randomness is an illusion: The appearance of randomness is only a sign of our ignorance and inability to detect the pattern. We can define a random outcome as one without perceivable cause or design, inherently unpredictable. We sometimes choose between options "at random", and if we toss a coin, we know it will land heads or tails "at random". When an event takes place as the confluence of totally unrelated events, it may appear to be so surprising and bizarre—for instance, when a man is hurrying down a street in response to a sudden phone call at the same time that a roof worker accidentally drops a hammer which hits the unfortunate pedestrian head—that we say the outcome is due to "blind chance." But are events such as these truly random? In this thought-provoking book, the author—a mathematician—shows how order and randomness are really two sides of the same mysterious coin.

Chater, N., & Oaksford, M. (1999). The probability heuristics model of syllogistic reasoning. *Cognitive Psychology, 38*(2), 191-258. In this paper the author suggest a probability heuristic model for syllogistic reasoning and confirms the rationality of this heuristic by an analysis of the probabilistic validity of syllogistic reasoning which treats logical inference as a limiting case of probabilistic inference. Meta-analysis and two experiments involving 40 adult participants and using generalised quantifiers support the model.

Dupuis, C., & Roousset-Bert, S. (1998). De l'influence des representations disponibles sur la resolution de problèmes élémentaires de probabilité et sur l'acquisition du concept d'indépendance. [Influence of available representations on the solution of elementary problems of probability and on the acquisition of the concept of independence]. *Annales de didactique et de sciences cognitives*, 6, 67-87. At the first stages of probability teaching, which changes between which registers of representation can be introduced in order to help understanding? The use of models congruent to natural language, the use of so called familiar situations or the restriction to symbolic expressions cannot help pupils to understand, for example, independence in probability. Introducing tree diagrams and cross tables representations in probability is helpful for constructing the meaning of probabilistic independence.

Granberg, D. (1999). Cross-cultural comparison of responses to the Monty Hall Dilemma. *Social Behavior and Personality, 27*(4), 431-438. A total of 935 college students in Brazil, China, Sweden, and the US were compared as to how they responded to the Monty Hall Dilemma. In each culture, there was a significant tendency to stick. On this type of problem, the 4 cultures did not differ significantly.

Hertwig, R., & Gingerenzer, G. (1999). The "conjunction fallacy" revisited: How intelligent inferences look like reasoning errors. *Journal of Behavioral Decision Making*, 12(4), 275-305. Research on the "conjunction fallacy" have been taken as evidence that our minds are not designed to work by the rules of probability. This conclusion springs from the idea that norms should be content-blind. In this study, the authors first show that people infer nonmathematical meanings of the term "probability". Then, it was demonstrated that one can design contexts in which people infer mathematical meanings of the term and are therefore more likely to conform to the conjunction rule. Evidence is reported that the term "frequency" narrows the spectrum of possible interpretations of "probability" down to its mathematical meanings, and that this fact accounts for the low proportion of violations of the conjunction rule when people are asked for frequency judgements.

Lee, J. T. (1998). Normal approximation to the binomial distribution. *Journal of the Korea Society of Mathematical Education* Series A, *37*(2), 227-231. Students invariably ask the question "What are conditions concerning which values of n and p are appropriate for using normal approximation to the binomial distribution?" In this article we compare the accuracy of several conditions for the approximation. Also we give some general conclusions concerning when to use the normal approximation.

Levin, J. R., & Robinson, D. H. (2000). Rejoinder to Cahan: statistical hypothesis testing, effect-size estimation, and the conclusion coherence of primary research studies. *Educational Researcher*, *29*(1), 34-36. Support, in the form of both a fable and a framework, is provided for a two-step approach to the estimation and discussion of effect sizes. A distinction is made between single-study decision-oriented research and multiple-study syntheses. The concept of "conclusion coherence" (the consistency between statistical and verbal inference) is introduced and illustrated within each investigative context.

Levin, J. R., & Serlin, R. C. (2000). Changing students' perspectives of McNemar's test of change. *Journal of Statistical Education*, *8*(2). An alternative perspective is presented for teaching students the logic and details underlying McNemar's test of the equality of correlated proportions. The new perspective enables straightforward extension to other correlated proportions situations.

Lewis, C., & Keren, G. (1999). On the difficulties underlying Bayesian reasoning: A comment on Gigerenzer and Hoffrage. *Psychological Review*, 106(2), 411-416. G. Gigerenzer and U. Hoffrage (1995) suggested that formulating problems in frequentistic terms would facilitate the practice of Bayesian inference. The authors suggest two different factors at work in this context: the use of frequency or probability statements and the use of joint or conditional sampling information. An experiment is reported demonstrating that, even with the use of frequency statements, Bayesian reasoning is more difficult with conditional than with joint information.

Mellers, B. A., & McGraw, A. P. (1999). How to improve Bayesian reasoning: Comment on Gigerenzer and Hoffrage (1995). *Psychological Review,* 106(2), 417-424. G. Gigerenzer and U. Hoffrage (1995) claimed that Bayesian inference problems become computationally simpler when information is presented with

frequencies based on natural sampling. The authors show that performance can improve with either probabilities or frequencies, depending on the rareness of the events and the type of information presented. When events are rare, probabilities are more difficult to understand than frequencies. Furthermore, when the information is presented as joint and marginal events, nested sets become more apparent. The authors agree with Gigerenzer and Hoffrage that frequencies can improve Bayesian reasoning, but they attribute that improvement to the use of mental models that involve elements of nested sets.

Teigen, K. H., & Brun, W. (1999). The directionality of verbal probability expressions: Effects on decisions, predictions, and probabilistic reasoning. *Organizational Behavior and Human Decision Processes*, *80*(2), 155-190. The probability phrases discussed are of two distinct types, depending upon their positive or negative directionality. In four studies, college students responded to vignettes and probability phrases. Findings indicate that verbal expressions are not simply "vague" probability statements, but have a consistent message, with clear implications for inferential judgements.

Riniolo, T. C., & Schmidt, L. A. (1999). Demonstrating the gambler's fallacy in an introductory statistics class. *Teaching of Psychology, 26*(3), 198-200. This paper describes a classroom demonstration of the gambler's fallacy to illustrate misconceptions about random processes and how they affect statistical interpretation. Formal and informal feedback indicated that the demonstration was well received and recommended for future classes.

Stephenson, B., & Stern, H. S. (1998). A primer on the Bayesian approach to statistical inference. *Stats. The magazine for students of statistics*, 23, 3-9. Despite the increased level of Bayesian activity there is a large audience, including advanced statistics undergraduates, beginning statistics graduate students, and researchers outside of statistics, who are not aware of exactly what the differences are between the Bayesian approach to inference and the procedures commonly used under the heading frequentist inference. The goal of this article is to reach this audience by focusing on a simple example.

Vickers, B. (2000). A classroom study into the use of kinaesthetic methods in the teaching of probability theory of independent and random events. *Teaching Statistics web page*: http://science.ntu.ac.uk/rsscse/TS/vickers/vickers.html. The aim of this project is to test the theory that there are certain concepts in statistics which can only be learned effectively by experience and not by being taught in the conventional manner. In order to test the theory a non-equivalent control group, quasi-experimental, design with pre- and post-testing was used with two local schools: one for the experimental group, and one for the 'control' group. A lesson plan using the scientific method and teacher-led classroom discussion was designed where the theories to be tested were constructed by the students as part of the experimental approach. Teacher-facilitated classroom discussion was used at key points to enable the students to learn from what they had just done. The data were gathered by using two schools of similar intake. One school became the 'control' group. The same pre- and post-test questionnaire was administered to both groups. The mean number of correct answers was used as the experimental variable. Comparison of the post-test questionnaire for both groups showed an improvement in the mean number of correct answers equivalent to 1.8 standard deviations.

10. Complementary Short References

Allen, J. B., & HUBERTY, C. J. (1995, October). GRE versus statistics performance. *GERA,* Atlanta, GA.

Altman, D. G. (1998). Statistical reviewing for medical journals. *Statistics in Medicine 17*, 2661-2674.

Burghes, D. (2000). The big ticket: How not to design a game show. *Teaching Statistics, 22*(2), 37-40.

Cobb, P. (1999). Individual and collective mathematical development: The case of statistical analysis. *Mathematical Thinking and Learning, 1*, 5-43.

Croucher, J. S. (2000). Using probability intervals to evaluate long-term success. *Teaching Statistics, 22*(2), 42-44.

Eisenhauer, J. G. (2000). The Monty Hall Matrix. *Teaching Statistics, 22*(1), 17-20.

Deshpande, M. N. (2000). Intransitive dice. *Teaching Statistics, 22*(1), 4-5.

FULLER, M. (2000). Six billion characters in seach of an author. *Teaching Statistics, 22*(2), 49-25.

Gibson, B. (2000). How many Rs are there in statistics? *Teaching Statistics, 22*(1), 22-24.

Graham, A. (2000). More statistical nuggets with a graphics calculator. *Teaching Statistics, 22*(1), 11-16.

HUBERTY, C. J. (2000). Assessment of student performance in statistics. *Teaching Statistics, 22*, 44-48.

HUBERTY, C. J., Dresden, J., & Bak, B. G. (1993). Relations among dimensions of statistical knowledge.*Educational and Psychological Measurement, 53*, 523-532.

Presley, R. J., & HUBERTY, C. J. (1988). Predicting statistics achievment: A prototypical regression analysis. *Multiple Linear Regression Viewpoints, 16*(1), 36-37.

HUBERTY, C. J. (1995, April). Student development of a philosophy of empirical research. *AERA,* San Francisco.

HUBERTY, C. J., & Smith, D. U. Measures of discrimination among achievement levels in statistics. *AERA,* Washington, DC, 1975.

HUBERTY, C. J., & Perry, M. D. Assigning junior high school students to levels of instruction in mathematics. *SEPA,* Atlanta, 1975.

Hunt, N. (2000). Pictograms in Excel. *Teaching Statistics, 22*(2), 56-58.

Konold, C., & Pollatsek, A. (1999). Center and spread: A pas de deux. Paper presented at the *Research Presession of the Annual Meeting of the National Council of Teachers of Mathematics.* San Francisco.

Konold, C. (1999). Statistics goes to school. *Contemporary Psychology, 44*(1), 81-82.

KORDOS, J. (2000). Jeszcze o edukacji statystycznej na studiach ekonomicznych [Further thoughts on statistical education in economic studies], *Kwartalnik Statystyczny, 1*(5), 47.

KORDOS, J. (2000). Szkolenie statystyków europejskich—Instytyt TES [Training of European Statisticians—Institute TES], *Kwartalnik Statystyczny, 2*(6),45-46.

Lillestol, J. (2000). Data have no meaning when separated from their context. *Teaching Statistics, 22*(1), 27-29.

Matthews, R. (2000). Storks deliver babies (p=.008). *Teaching Statistics, 22*(2), 36-37.

Meacock, S. (2000). A statistics field trip? *Teaching Statistics, 22*(1), 7-10.

Nelder J. A. (1999). Statistics from the millenium. From statistics to statistical science. *The Statistician, 48*, 257-269.

Perks, P., & Prestage, S. (2000). Bar and pie charts. Ideas for the classroom. *Teaching Statistics, 22*(2), 52- 55.

Presley, R. J., & HUBERTY, C. J. Predicting statistics achievement: A prototypical regression analysis. *AERA,* Washington, 1987.

Simmonite, V. (2000). Two-way interactions. They're top of the pops. *Teaching Statistics, 22*(2), 58-60.

11. Information on Past Conferences

11.1. Statistics Education Presentations at the American Educational Research Association Annual Meeting, New Orleans, April, 2000

Carol BLUMBERG and Joan B. GARFIELD

Note: Most of the material in this report is taken from Carol Joyce BLUMBERG's article in a recent ASA Stat Ed Newsletter.

The *American Educational Research Association* (*AERA*) has approximately 22,000 members and is "concerned with improving the educational process by encouraging scholarly inquiry related to education and by promoting the dissemination and practical application of research results" (quoted from *AERA* webpage at www.aera.net). It is made up of 11 main divisions. Parallel to the divisions are almost 200 Special Interest Groups (SIGs), one of which is the SIG—Educational Statisticians. The purpose of the SIG—Educational Statisticians is to increase interaction among educational researchers interested in the theory, applications, and teaching of statistics in the social sciences. Most papers related to statistics education are sponsored by this SIG. This year they included the following papers.

The invited presentation was by Roxy *PECK* (California Polytechnic State University)*on Advanced Placement Statistics: The curriculum, the examination and the grading process.* The discussant for this session was Chandler Pike (Mercer University). Roxy and Chandler prepared a handout that is available from Roxy at <rpeck@calpoly.edu>. The first symposium *Reconsidering outcomes of statistics courses: statistical literacy, reasoning, and thinking* was organized by Joan B. GARFIELD. The papers in this session were:

- *Statistical literacy as a goal of introductory statistics courses* by Deborah J. *RUMSEY*, Kansas State University <rumsey@math.ohio-state.edu>

- *The role of statistical reasoning in learning statistics* by Joan B. GARFIELD, University of Minnesota <jbg@tc.umn.edu>, and

- *What is statistical thinking and how can it be developed?* by Beth CHANCE, California Polytechnic State University <bchance@calpoly.edu>.

The second symposium *Teaching multivariate statistics: perspectives on curriculum and assessment* was organized by Ann O'Connell. The papers in this session were:

- *Curriculum and sequencing issues in multivariate analysis* by Sharon L. Weinberg, New York University <slw1@is2.nyu.edu**>**,

- *Approaches to assessment in multivariate analysis* by Ann O'Connell, University of Connecticut <oconnell@uconn.edu>,

- *Teaching advanced topics in multivariate analysis* by Jorge L. Mendoza, University of Oklahoma <jmendoza@psychology. psy.ou.edu>, and

- *Incorporating matrix algebra in multivariate analysis courses: building on univariate prerequisites and algebraic competencies* by Ron C. Serlin, University of Wisconsin, Madison <rcserlin@facstaff.wisc.edu>.

The papers (in alphabetical order by first author's last name) that were given in formal paper sessions or as roundtables are:

- *The teaching of statistical consulting skills* by Gabriella M. BELLI, Virginia Tech <gbelli@vt.edu>

- *Recovery of the underlying cognitive representations used by novices and experts to compare statistical tests* by Maria E. Bravo, University of Texas, Austin <bravo@vvm.com>

- *Selection and use of propositional knowledge in statistical problem solving* by Nick J. Broers, and Martijn P. F. Berger, Maastricht University <nick.broers@stat.unimaas.nl>

- *Investigating the organization of ten concepts in introductory statistics* by Mark A. EARLEY, University of Toledo <markstat98@aol.com>

- *The meaning of success for students in statistical methods courses: A Phenomenological Study* by Sara J. Finney, University of Nebraska, Lincoln <sfinney@unlserve.unl.edu>

- *Predicting acquisition of learning outcomes: a comparison of traditional and activity-based instruction in an introductory statistics course* by Jenenne A. Geske, William T. Mickelson, Deborah L. Bandalos, Jessica Jonson, and Russell W. Smith, University of Nebraska, Lincoln (jgeske@unlserve.unl.edu)

- *Constructivist approaches to learning probability in the first statistics course using authentic learning and assessment tasks* by Carolyn M. Keeler, and R. Kirk Steinhorst, University of Idaho (ckeeler@ uidaho.edu)

- *Effect of calculator technology on student achievement in an introductory statistics Course* by Kathleen C. Mittag, and Linda B. Collins, University of Texas, San Antonio (kmittag@ utsa.edu)

- *Understanding students' statistical thinking: error analysis approach* by Fadia M. Nasser, Tel Aviv University (nasser@beitberl.ac.il)

- *How should we teach follow-up tests after significant interaction in factorial analysis of variance?* By T. C. Oshima, and Frances McCarty, Georgia State University (oshima@gsu.edu)

- *Toward "constructing" the concept of statistical power: an optical analogy* by Bruce G. Rogers, University of Northern Iowa (bruce.rogers@uni.edu)

- *A call for teaching more hypothesis testing in educational statistics classes* by Michael A. Seaman, University of South Carolina (mseaman@sc.edu)

- *Web-based readings for an introductory statistics course* by Joseph M. *WISENBAKER*, University of Georgia and Cordelia Douzenis, Georgia Southern University (joe@coe.uga.edu).

In addition to papers sponsored by the SIG—Educational Statisticians, the following paper on statistics education was also presented at *AERA*:

- *You want me to teach statistics? a study of preservice teachers' efforts to integrate reasoning with data into the K–6 curriculum.* Ruth Heaton, and William Mickelson, University of Nebraska, Lincoln.

Symposium: Supporting the Learning of Classroom Communties: A Case from Middle School Statistics

Papers:

- *Learning about data analysis:* Paul Cobb, Vanderbilt University

- *Learning about data creation,* Carrie Tzou, Vanderbilt University

- *Supporting students' mathematical development.* Kay McClain, Vanderbilt University

- *From research-initiated experiment to teacher-owned practice,* Mary Singer Gabella, and Nora W. Shuart, Vanderbilt University

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11.2. La Fouille dans les Données par la Méthode d'analyse Statistique Implicative (Data Mining by Statistical Implicative Analysis), Caen, France, June 23-24, 2000

Régis GRAS

The conference was held at the Institut de Formation des Maîtres, Caen, France on June 23-24. The theme of these international conference, that was sponsored by *IASE* was "implicative analysis". Carmen BATANERO and Maria-Gabriela OTTAVIANI took part in the Scientific and Programme Committee.

"Knowledge Discovery in Databases" or "Data Mining" start, in general by crossing subjects (or objects) and binary or ordinal variables (properties or attributes). Implicative analysis aims to extract invariant knowledge, non-symmetric, consistent rules such as "the attribute a implies the attribute b". It is statistically based on a significant number of cases confirming the rule. The software CHIC (Classification Hiérarchique Implicative et Cohésitive) allows us to quantify the significance of this number, the rule consistency, classes of rules, and subject's or subject categories' contributions to the rules. It serves to represent in a graph, the rule chains and in a hierarchy rules on the rules, such as to add, delete, join or decompose variables.

Among the sessions papers from Italian, Spanish, Belgium and French researchers showed significant results obtained in the application of different domains. Implicative analysis served to complement factorial or cluster methods, to find rules on workers' management in a business, rules on consumers' attitude, stable links in biology, learning invariants in psychology of learning, didactics and education, rules of social representation, etc.

The plenary lecture by Régis GRAS and Yves Kodratoff presented the theory on this method and its application to the analysis of literary texts. At the workshops, participants were introduced to the software CHIC. Using an example and a file with binary data they could do the first theoretical computation and then validate its results from the software results. This activity tried to demystify the automatic calculus algorithms and lead to a more critical and expert interpretation of the method results.

In the middle of the conference a Normandy dinner showed the quality of local cuisine and products, and also to contribute to establish exchanges among participants. The proceedings with all the contributions will be published in the near future.

11.3. Stochastics Papers at MERGA Conference, Fremantle, Western Australia, July 2000

There were seven stochastics papers within at least three different theoretical frameworks presented at this Conference. Abstracts (together with page numbers) are provided below, and copies of the Proceedings may be obtained by writing to MERGA, c/- Jon Ladbrooke, 21/219 Kissing Point Road, Turramurra, New South Wales 2074. Fax +612 9144 7544. <mergapub@tpgi.com.au>. Prices (including postage) are: Australia, A$55; New Zealand A$70; Rest of the world, A$80. MERGA personal members above prices less A$10. Visa and Mastercard are accepted or a cheque or bank draft in Australian dollars.

The full bibliographic reference of the Proceedings is: Bana, Jack, Chapman, Anne (Eds.) (2000). *Mathematics Education Beyond 2000* Proceedings of the twenty-third annual conference of The Mathematics Education Research Group of Australasia Incorporated held at Fremantle, Western Australia, 5–9 July, 2000. Sydney, New South Wales: The Mathematics Education Research Group of Australasia Incorporated.

Papers

Burgess, T. *Are teachers' probability concepts more sophisticated than those of their students?* (vol. 1, pp. 126–133). The probability concepts of a group of pre-service primary teachers were investigated and classified in relation to known misconceptions as well as within a framework that identifies levels of understanding. These results were compared with the misconceptions exhibited by a group of 11 and 12 year old students. The major question investigated was whether these prospective teachers showed more sophisticated probability concepts than 11 and 12 year old students.

Chick, H. *Young adults making sense of data.* (vol. 1, pp. 157–164).Young adults were presented with raw data involving a number of variables and asked to produce a report that highlighted any "interesting aspects" that they observed. The approaches taken varied from simple frequency information through to scatter plots and the use of ratios to consider the relationships between three variables. Although the use of sophisticated statistical techniques was not expected, the limited use of even basic techniques was surprising, given the increased emphasis on Chance and Data in school curricula.

Moritz, J. *Graphical representation of statistical associations by upper primary students.* (vol. 2, pp. 440–447). Students' graphical representations of statistical associations are explored through analyses of responses from 97 students in grades 4, 5, and 6. The task involved representing (a) the association "People grow taller as they get older", (b) this association with an age modifier, and (c) this association with sex differences. Three levels of representing bivariate associations and of representing multivariate associations are described: unsuccessful.

Moritz, J., & WATSON, J. *Reasoning and expressing probability in students' judgements of coin tossing.* (vol. 2, pp. 448–455). A survey item based on a newspaper article about coin tosses was administered to 1256 students from grades 6 to 11. Few students 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.

PFANNKUCH, M. *A model for the promotion of statistical thinking?* (vol. 2, pp. 503–510). This paper presents a model for statistical thinking in empirical enquiry, based on practitioner behaviour. The conjectured types of thinking that are fundamental to the statistics discipline are then used to analyse an assessment item and teaching situation. It is concluded that such an analysis is possible and that more discussion and research is needed on defining, clarifying, and articulating the statistical thinking that is embedded and inherent in statistical practice.

Putt, I., Perry, B., JONES, G., Thornton, C., Langrall, C., & Mooney, E. *Primary school students' statistical thinking: a comparison of two Australian states.* (vol. 2, pp. 519–526). A framework for teaching and assessing statistical thinking comprising four constructs and four levels for each construct, has been developed and the framework validated using data from 20 US students in Years 1–5. The same validation procedures were implemented in two different cohorts, totalling 40 subjects, of Australian students in Years 1–5. Lower levels of coherence were found. This paper reports the Australian data, seeks to address reasons for the differences and compares the levels of performance between Australian and US students.

WATSON, J. *Intuition versus mathematics: the case of the hospital problem.* (vol. 2, pp. 640–647). This paper considers 33 preservice secondary mathematics teachers' solutions to a famous sampling problem, well known for confounding educated adults. Of particular interest is the Bachelor of Teaching students' use of intuition and/or formal mathematics in reaching a conclusion. The relationships of solution strategy to students' background in formal mathematics and gender are also considered. Implications for teaching statistics at both the secondary and preservice teacher education levels are discussed briefly.

As well as these papers, there were also two papers by John and Kath TRURAN which examined aspects of the refereeing process for Conferences. This is an issue which has concerned a number of stochastics authors submitting papers to mathematics education conferences, but the papers did not address the specific issues of concern to stochastics writers.

11.4. Stochastics Papers at PME Conference, Hiroshima, Japan, July 2000

These papers have been published in Nakahar, T., & Koyama, M. (Eds.) (2000). *Proceedings of the 24th Conference of the International Group for the Psychology of Mathematics Education.* Hiroshima, Japan: Hiroshima University. Copies may be obtained by writing to the PME secretariat Joop van Dormelen <joop@tx.technion.ac.il>. Prices are not yet available.

Short Oral Communications

Da Costa, N., Healy, L., & Magina, Sandra. *Primary teachers' interpretations of graphical representations: differences between static and dynamic data analysis.* (vol. 1, p. 150).

NICHOLSON, J., & Mulhern, G. *Teaching and learning statistics: diagnostic and support materials for teachers and students.* (vol. 1, p. 174)

Suehiro, S. *An analysis of a Japanese high school student's ability to interpret graphs.* (vol. 1, p. 188)

Poster Presentations

Barra, M. *Relationship between probability and other languages used in the sciences. The Pythagorean "Aritmo-geometry" expanded to d-dimensions and in the continuum of the discrete spaces. A didactic proposal.* (vol. 1, p. 199)

Research Reports

Ainley, J. *Exploring the transparency of graphs and graphing.* Vol. 2, pp. 9–16). The increasingly wide-spread use of graphs in advertising and the news media seems to be based on an assumption, widely challenged by research evidence in mathematics and science education, that graphs are transparent in communicating their meaning. Meira's (1998) view of transparency as emerging through use, rather than as being an inherent feature of instructional devices, is used to consider the transparency of graphs, and question traditional curriculum design.

AYRES, P., & WAY, J. *Knowing the sample space or not: the effects on decision making.* (vol. 2, pp. 25–32). Grade eight students observed a video-recording of coloured balls being drawn from a box with replacement. After every fifth selection, students were required to predict the colour of the next ball drawn. It was discovered that knowing or not knowing the sample space made no difference to predictions. However, students were significantly influenced in their probability judgements by confirmation or refutation of their own 'predictions'. Furthermore, interviews revealed that many students inappropriately tried to utilise colour patterns as a strategy.

CARVALHO, C., & CÉSAR, M. *The game of social interactions in statistics learning and in cognitive development.* (vol. 2, pp. 153–160). This investigation is part of the project Interaction and Knowledge, whose main aim is to promote social interaction as one of the possible forms of pupils' socialisation, develop positive attitudes towards Mathematics, promote their socio-organic development and enhance their school achievement. Comparing the cognitive progress and mathematical performances of pupils working in dyads with those who did not work this way, the former show higher progress,

English, L, Charles, K., & Cudmore, D. *Students' statistical reasoning during a data modelling program.* (vol. 2, pp. 265–272). This paper reports on the first year of a 3-year international project addressing ninth- and tenth grade students' statistical reasoning processes as they participate in a range of data modelling experiences. These experiences engage students in constructing statistical problems and cases, as well as in reasoning critically and philosophically. Among the first-year findings is the need to develop further students' (a) knowledge of statistical measures and data representations to enable them to construct problems and cases that are not statistically naïve; and (b) abilities to reason more critically about the statistical issues and arguments they are advancing.

JONES, G., Langrall, C., Thornton, C., Mooney, W., Wares, A., Perry, B., Putt, I., & Nisbet, S. *Using students' statistical thinking to inform instruction.* (vol. 3, pp. 95–102). This study designed and evaluated a teaching experiment in data exploration for a grade 2 class. The teaching experiment was informed by a cognitive framework that described elementary students' statistical thinking. Following the teaching experiment, the children showed significant gains on all four statistical processes associated with the framework. Case-study analysis revealed that: experiences with different kinds of data reduced children's idiosyncratic descriptions, categorical data was more problematic than numerical data; technology was helpful in stimulating children's ability to organise and represent data, children possess prior conceptual knowledge of centre and spread; context was important when children analysed data.

Nisbet, S., & Bain, J. *Listen to the graph: children's matching of melodies with their visual representations.* (vol. 4, pp. 49–56). This paper is a report of matching of melodies with line graphs and music notation by children (aged 10 and 11 years). The study found that children are able to match the up and down contour of melodies with their visual representations, and that matching-task performance is positively related to mathematical ability in the case of the line graphs, and musical ability in the case of the music notation,. The results suggest that visually impaired students and students with a preference for aural learning may be able to perceive the shape of graphs through auditory output of graphical calculators or computers. It was found also that the children were using global processing more readily than local analytic processes and were able to detect global features such as overall shape more easily than local details such as interval sizes.

Perry, B., Putt, I., JONES, G., Thornton, C., Langrall, C, & Mooney, S. *Elementary schools students' statistical thinking: an international perspective.* (vol. 4, pp. 65–72). Based on a review of the statistical literature and Biggs and Collis' (1991) neo-Piagetian general development model, the authors have formulated and validated a framework for assessing and fostering elementary students' statistical thinking. The framework comprises four key constructs: describing, organising & reducing, representing, and analysing & interpreting data. The same validation procedures were implemented on two different cohorts: 20 USA and 40 Australian students in grades 1 through 5. The data confirmed four levels of statistical thinking for each

construct. However, the degree of consistency with respect to the framework was different for the USA and Australian samples.

READING, C., & SHAUGHNESSY, M. *Student perceptions of variation in a sampling situation.* (vol. 4, pp. 89–96). Variation is essential to the study of statistics, but may be a neglected topic in school mathematics. Although students may recognise that variation will occur in a sampling situation they have difficulty in discussing reasons for this variation. Three forms of an item were trialed in clinical interviews with students in grades 4–12. The interviews probed for students' understanding of centres and spreads which can occur in the resulting sampling distribution for repeated trial of an experiment. This paper contains four case studies of students' reasoning during the interviews.

TRURAN, J. *Children's learning of independence: can research help?* (vol. 4, pp. 209–216). A Handbook Model is used to codify research results about children's understanding of independence so that it is accessible to practising teachers and indicates useful future research. Given the imprecise world of the classroom, such an approach requires the development of appropriate criteria for linking research and practice.

Discussion Group 6: Stochastical Thinking, Learning and Teaching

As well a the usual social opportunities and an evening at a restaurant, the Group discussed three short presentations on "The Relationship between Stochastical and Mathematical Thinking, Learning and Teaching".

Mario Barra (Italy) spoke on "The relationship between probability and geometry: a didactic use", and looked at connections between probability, which is very abstract, and geometry, which is concrete and allows students to visualise relationships. For example, he took a cube of 6 x 6 x 6 small cubes and considered how many of the small cubes have at least one extreme position. (This is equivalent to throwing a six on at least one of three dice.) Examining the different ways in which the cubes can be counted illuminated different probability forms and Mario argued that this is a powerful way for geometric thinking to assist more abstract probability thinking.

Jenni WAY and Paul Ayres (UK/Australia) spoke on "The relationship between pattern and randomness". They showed how their studies with Australian students had revealed the insistence of many children to look for patterns in a series of random outcomes. This is perhaps because current mathematics teaching emphasises patterns and highlights a conflict between probabilistic thinking and mathematical thinking.

James NICHOLSON (Northern Ireland) spoke on his work with Gerry Mulhern on "Perspectives from Students and Teachers on the Differences in Thinking in Mathematics and Statistics". In school mathematics outcomes are almost always unique, though there may be multiple approaches possible which arrive at the same 'solution'. In statistics, however, students must do some things which are 'purely mathematical', but also provide answers requiring judgement, and so it is possible to have different answers, each of which has some merit. He presented some classroom techniques for addressing this issue, including the use of consultancies and data sets capable of different reasonable interpretations.

Numbers this year were quite small (twelve participants), but the discussions were fruitful and provided some practical ways of addressing the differences between stochastic and mathematical thinking. A more detailed summary of the discussions may be found at http://www.beeri.org.il/stochastics/. The same format has been approved for the next PME meeting in Utrecht in July 2001.

11.5. ICME-9 Tokyo/Makuhari, Japan, July 31 to August 6, 2000

TSG4 The Teaching and Learning of Statistics. Organisers: Susan STARKINGS, (UK), Chair, Theodore CHADJIPADELIS (Greece), Michimasa Kobayashi (Japan), Tae Rim LEE (Korea), Toshiyuki Nakano (Japan).

Summaries of papers

Elena CARRERA, Universidad Nacional del Litoral, Argentina. *Teaching statistics in the first years of University with emphasis in the solution of problems.* After the last educational reformation our country has recently begun to introduce emphasis in Statistics, with emphasis in the pre-grade curricula. Until recently only

graphs, means and standard deviations were taught, and sometimes other measures of position. The need to achieve a balance between two conflicting approaches is discussed. On one handis a teaching-learning process based in the mathematical aspects of the construction of statistical knowledge. On the other hand is an emphasis on the use of the instruments, without any necessary understanding of their foundation. These considerations have led us to write a little book which is being printed in the belief that most introductory texts do not adequately explain the concepts which underlie the whole subject of statistics, and in many cases are divorced from reality. This book should provide an understanding of the principles and concepts which underlie data analysis and the interpretation of results. Real data have throughout been used, mostly from published papers, and we have tried to select data which are interesting in their own right.

Hans-Joachim MITTAG, University of Hagen, Germany. *Multimedia and multimedia databases for teaching statistics.* Statistics seems to be particularily suitable for illustrating the benefits of multimedia-based teaching. On the one hand, Statistics connects quite different fields of application. This interdisciplinary character of the science can be well demonstrated by suitable videos and motivating examples closely related to people's life. On the other hand, multimedia represents an ideal platform for visualizing statistical concepts and for discovering basic statistical principles by self-driven experiments. The German State of North-Rhine Westphalia launched in 1998 a multimedia University network program aiming at building up innovative WWW-supported educational software prototypes for a broad range of sciences. Within this framework a multimedia software (in German) was developed at the Distance University of Hagen in the period January 1998 December 1999 as an interdisciplinary project involving a chair for Statistics and Econometrics and a chair for Applied Computer Sciences.

Joe WISENBAKER, Janice S. Scott - University of Georgia, USA & Fadia Nasser - Tel Aviv University, Israel. *Structural equation models relating attitudes about and achievement in introductory statistics courses: A comparison of results from the U.S. and Israel.* The difficulties that many students, particularly those in the social and behavioral sciences, encounter while taking an introductory statistics course have been widely reported in many parts of the world. Factors that have been purported as relating to performance in introductory statistics include a variety of cognitive and affective variables. A major issue concerns the influence of attitudes on achievement. Longitudinal studies of math attitudes and performance (Pajares & Miller, 1994; Meece, Wigfield, & Eccles, 1990; Eccles & Jacobs, 1986) have provided path analyses of the relationship of these variables.The research reported here extends that line of inquiry looking at data from English and Arabic speaking samples available in the U.S. and Israel.

Ruslan MOTORYN, Kiev National University of Economics, Ukraine, *The teaching and learning of international statistics in transitional country: Case of Ukraine.* In 1993 the new government of the Ukraine confirmed the beginning of the transition of the National Ukrainian Statistics to the International Standards. Now the Ukraine has moved from a planned to a market economy in the areas of productive forces, structure of economy, the integration of its economy with the international economy and the social role of the state institutions. The three-stage planned realisation of the plans are: 1) Preparatory. The determination of organisational, methodical, fundamental, and essential principals of the transition of the Ukrainian statistics to international standards. 2) Transitional. Introduction of these principles to the practice of statistics. 3) Final. The attainment of the integration of all spheres of statistical activity. Now Ukrainian statistics has reached to the second stage. The importent task for Ukraine is the training of specialists of the Economic Statistics for the market economy. Therefore the content of teaching Economic Statistics is moving to the International Standards and incorporating knowledge about international statistics needed for specialists of economics, management, statistics, international economy *et cetera.* I describe in detail the course in International Economic Statistics for economics students in Ukrainian Universities. In this paper only the problems the statistics of population, labour, industry, agriculture, trade, prices and the Systems of National Accounts are considered.

Corinne Hahn, Chambre de Commerce et d'Industrie de Paris, France.*The use of a multimedia tool in teaching factor analysis to business school students. Is there a statistical significant improvement?* Teaching factor analysis to non scientific audience is not easy. These methods should be taught with rigor so that students develop the capacity to interpret the results of the statistical analysis correctly. But it cannot be taught in too theoretical a way because it would be rejected by students who often have a difficult relationship with mathematics (Dassonville et Hahn, 1999). The development of technology, especially multimedia, has allowed the consideration of new pedagogical tools which could improve learning (Legros, 1997). But we know that human mediation is an essential part of the process of knowledge construction (Tall, 1994;

Linard, 1998). So, the question of the position of such tools in a pedagogical programme is still fundamental. It is why the Paris Chamber of Commerce and Industry supported a research project on learning Principal Components Analysis (PCA). The first step of this project was to create a multimedia tool (Dassonville, 1997). The second step was to evaluate the efficiency of the tool. In our presentation, we will first say a few words about teaching of statistics in French Business schools. Then describe shortly the pedagogical programme we experimented at Ecole Supérieure de Commerce de Paris (ESCP), integrating the multimedia tool. Then we will present the main results of the evaluation of this tool's efficiency which we conducted in 1998/99.

Maria da Graca Pereira, GEIASC, Brazil, *Demonstrative prototype of the statistical methods.* This paper deals with the introduction of hypermedia technologies in statistical methods as well as their applications in the training of students. A hypermedia prototype to show statistical methods was developed using the toolkits of Toolbook and Kappa. Several screens were developed into an electronic book. The screens show the calculations modules. Some statistical graphs are showed through the screens. The electronic book shows about theoretical methods for calculating means, medians and variance for samples, and it provides a deep knowledge about statistical methods. The consultation sessions are quite complete, allowing the student to learn the theory and practice to solve statistical problems. A hypertext system represents the information in a different way from others usually employed, because it is presented as a non-linear mode and, therefore, allowing users to seek advice and information in accordance with their interests. The paper discusses publications which suggest the benefits of hypermedia systems applications in personal training models.

James NICHOLSON & Gerry Mulhern, Queen's University of Belfast, UK. *Conceptual challenges facing A-level statistics students: teacher and examiner perspectives.* This study sought to investigate perceptions of students' conceptual challenges among A-Level statistics teachers and examiners. The nature and extent of participants' insights were assessed using a questionnaire administered in either written form or via a semi-structured interview. The questionnaire comprised two sections: (i) free-response questions in which participants were asked to list the three most significant conceptual challenges faced by students; and (ii) an attitude scale designed to assess agreement with specific statements regarding possible conceptual challenges. Each section addressed five topic areas: regression and correlation, estimation, sampling methods, distribution modelling, and general statistical thinking. Twenty participants (15 teachers, 5 examiners) completed the questionnaire. Preliminary results suggest interesting patterns of agreement and disagreement in teacher and examiner perspectives.

Hiroaki Hirabayashi, Osaka Women's Junior College, Japan. *How do we arouse students' interest in statistics? - by development of teaching materials.* In Japan, many students in women's junior college dislike statistics. In order to arouse students' interest in statistics, we had tried to develop teaching materials for many years and succeeded in arousing their interest in statistics.

Graham JONES, Illinois State University, USA, Bob Perry University of Western Australia, Ian Putt, James Cook University, Australia & Steven Nisbet, Griffiths University, Australia. *Assessing and fostering children's statistical thinking.* In response to the critical role that information plays in our technological society, there have been international calls for reform in statistical education at all grade levels. Notwithstanding these calls for reform, there has been relatively little research on children's statistical thinking and even less research on the efficacy of instructional programs in data exploration.   In this paper, we will discuss how our research has built and used a cognitive model to support instruction in data exploration. More specifically, the paper will: (a) examine the formulation and validation of a framework that describes students' statistical thinking on four processes; and (b) describe and analyze teaching experiments with grades 1 and 2 children that used the framework to inform instruction.

Margarida CÉSAR & Carolina CARVALHO, University of Lisbon, Portugal. *How to do this? Working together in an unusual statistical task.* In the literature means, modes and medians are referred as measures of central tendency and they are important concepts in data handling and analysis. Some authors (BATANERO et al., 1994; CARVALHO, 1996, 1998; Cudmore, 1996; HAWKINS, JOLLIFFE and Glickman, 1991) also stress that students have difficulty with these basic concepts and to some of them these concepts can be reduced to a computation formula.The main goal of this study was to analyse peer interactions in order to understand their role in pupilsí performances when they were solving statistical tasks. A deep analysis of their discourse makes clear the way they construct an intersubjectivity (Wertsch, 1991) that facilitates the choice of the solving strategies and helps pupils to undertake their mistakes.

Parul Deoki, The University of the South Pacific, Fiji. *Understanding the mean and the expected value.* The paper will illustrate what the students in an Introductory Statistics course at the University of the South Pacific said that the mean was in an answer to an exam question. Whereas all the students know how to work out the mean using the formula, very few could really explain satisfactorily what the mean really indicated or when to use it in real life other than saying that mean is such and such. The paper will also suggest how best to emphasize the different measures of central tendency, and in the case of mean why we call it the expected value, and of what use is the expected value.

For further information please contact: Susan STARKINGS: starkisa@vax.sbu.ac.uk or check the *IASE*, ICME-9 site http://www.swin.edu.au/maths/*IASE*/icme9.html or the full ICME9 site http://www.ma.kagu.sut.ac.jp/~icme-9/

11.6. *IASE* Round Table Conference on Training Researchers in the Use of Statistics
The Institute of Statistical Mathematics, Tokyo, Japan, August 7-11, 2000

The *IASE Round Table Conference on Training Researchers in the Use of Statistics* is part of a long international collaborative process, which started in 1997, when the past IASE Executive Committee selected the topic and nominated Carmen BATANERO to organise its scientific committee. Between 1997 to 1999 the conference was announced through the *IASE* and ISI publications, and through a number of statistics and mathematics education journals and its theme attracted wide interest on the part of statistician and statistics educators. *IASE* organised a refereeing process with participation of specialists from different countries to assure fairness and quality in the process of reviewing and selecting the papers which were finally presented at the conference from among the many proposals received. The *IASE* is grateful to the members of the Scientific Committee, professors CHADJIPELIS, GARFIELD, Miura, OSPINA and PHILLIPS for their work during the planning period and to the referees who were willing to contribute to this collective study with their expertise in different fields and topics and who provided many valuable comments to help the authors in developing their papers.

The conference was supported by the *ISI,* which also helped some participants trough the *ISI Development Fund. The Institute of Mathematical Statistics in Tokyo*, and its director Dr. Shimizu offered to hold this event and provided additional funds. It was for us a great honour to be hosted by this Institute, which is a leader in the statistical practice and research in Japan and at an International level. We also thanks the *Japan Statistical Society* for its support; in particular we thank the *Education Section*, and our colleagues Dr. Miura, Murakami, Shimada, and ARAYA for their work in arranging all the details of the local organisation, which made the conference most enjoyable and productive. We are sure that this meeting will serve to reinforce the *IASE* presence in Japan and the surrounding countries.

After the conference, the papers are being revised to take into account the discussions and suggestions during the conference. A monograph on the theme will be published in 2001 including the starting call for papers, the 24 papers presented and the reactions by the discussants. Below we include the conference programme and summaries of the papers.

Conference Programme

Opening: Dr. Ryoichi Shimizu, Director-General, The Institute of Statistical Mathematics, Japan, Dr. Yuki Miura, Japan Statistical Society, and Carmen BATANERO, International Association for Statistical Education

1. Training researchers in particular statistical topics
Session 1.1. Discussion: S.P. Mukherjee, Department of Statistics, Calcutta University, India and Martha ALIAGA, The University of Michigan, USA.

Elisabeth SVENSSON, Mathematical Statistics, Chalmers and Göteborg University, Göteborg, Sweden*: Important considerations for optimal communication between statisticians and medical researchers in consulting, teaching and collaborative research– with a focus on the analysis of ordered categorical data.* This paper focuses on problems encountered in the teaching of statistics to applied researchers working particularly with rating scales and questionnaires. Examples of teaching strategies will be presented that are designed to remove misconceptions and the misuse of statistics. Such strategies should increase the

level of understanding about the relationship between study design, measurement processes and the choice of statistical methods of analysis. A survey among applied researchers showed that tradition, the need to compare the results with other studies and a lack of knowledge of novel statistical methods were the major factors determining the choice of methods for evaluation of questionnaires. Besides pedagogic skills, professional competence and an open-minded inter-disciplinary understanding were the most important qualifications for optimal inter-professional communication.

Antonio ESTEPA, and Francisco T. SÁNCHEZ COBO, Facultad de Humanidades y Educación, Universidad de Jaén, Spain: *Empirical research on the understanding of association and implications for the training of researchers.* In this paper we summarise the main research findings on the understanding of association carried out in Psychology and Mathematics Education and we present results from an assessment study on the understanding of correlation and regression by university students. We finally discuss the implications of these results for designing courses directed to train researchers in the use of statistics.

Chihiro Hirotsu, Graduate School of Engineering, University of Tokyo, Japan, *Statistical training of the researchers for the Total Quality Management.* In this note we consider a training system of the statistical methods for TQC (Total Quality Control) or TQM (Total Quality Management). Then two important aspect will be what and how to teach. Ideally a company should have a TQM promotion team involving several tutors who are expert in the area and can teach those statistical approaches. However, some elementary courses may be more efficiently taught by an outside institute such as JSA (Japanese Standards Association) or JUSE (Japanese Union of Scientists and Engineers) in Japanese case.

Session 1.2. Discussion: *Theodore CHADJIPADELIS,* Department of Education, University of Thessaloniki, Greece

Ann-Lee WANG, Institute of Mathematical Sciences, University of Malaya, Kuala Lumpur, Malaysia. *how much stochastic processes do we teach and to whom?* Researchers quite often need to model and analyse real-world random phenomena using stochastic processes. Learning stochastic processes requires a good knowledge of probability theory, calculus, matrix algebra and a general level of mathematical maturity. Not all researchers have a good foundation in probability theory and mathematics. In this paper, we discuss the different approaches to the teaching of a first course in stochastic processes to researchers. Difficulties in the understanding of 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.

Alan MCLEAN, Monash University, Department of Econometrics and Business Statistics, Melbourne, Australia. *Statistics on the catwalk. The importance of models in training researchers in statistics.* This paper emphasises the pervasive role of probability models in statistics, and the importance of the role of prediction in statistics. I argue that all thinking, including everyday decision making, is based on the use of models: theories, stereotypes, metaphors, stories, myths, equations, diagrams, blueprints. Scientific thinking, including statistical thinking, is not different from 'everyday' thinking, but is a formalisation of it. Just as we 'learn from experience', a scientific theory is tested against observed data. Statistics is a body of techniques for developing and assessing models, particularly those involving uncertainty. This modelling process takes place at all levels of a statistical analysis, not only in 'model selection'. Examples are given to illustrate these processes. Particular attention is given to the role of hypothesis testing, showing how it is a form of model selection between two models, one of which is 'privileged'. Researchers, if they are to understand the role of statistics in scientific research, must understand the role of models in science generally and in statistics in particular.

Gudmund R. IVERSEN, Department of Mathematics and Statistics, Swarthmore College, Swarthmore, USA: *Why should we even teach statistics? A Bayesian perspective.* Statistical methods have an impact on the results of any statistical study. We do not always realise that the statistical methods act in such a way as to create a construction of the world. We should therefore be more aware of the role of statistics in research, and the question is not so much about what we teach researchers but that we train them to be aware of the impact of the methods they use. This becomes particularly important in statistical inference where we have the choice between the classical, frequentist approach and the Bayesian approach. The two approaches create very different views of the world. The word probability carries with it a notion of uncertainty, and it is tempting to think that the uncertainty refers to parameters and not simply data.

2. How technology affects the training of researchers. Discussion: *Kensey ARAYA,* Fukushima University, Japan

Sandra McDonald. Project Manager, Data Laboratory. Statistics New Zealand. *Practical and educational problems in sharing official microdata with researchers.* Presented by Megan CLARK, School of Mathematical and Computing Sciences, Victoria University New Zealand. Many commentators have noted the need for reform in statistical education. They tend to focus on the analytical techniques that are critical to understanding and producing good quality statistical outputs. This paper adds to these discussions and looks at some of the main analytical issues that transpire from the particular form of statistical databases in a national statistical office. However it also considers the more practical, but very important skills and knowledge, that a researcher needs, such as getting the data set in a format that is most useful to them, and ensuring they gain access to the data that will allow them to undertake their analyses.

Toshiro Shimada, Meiji University, Professor Emeritus, Tokyo, Japan. *Precaution against errors in using stochastic software.* There are many statistics packages available that make it easy to perform stochastic procedures. Therefore, today's students and researchers may think they can handle their data processing needs, and obtain stochastic results simply by clicking a PC button. However, without being aware of it, they can make many mistakes, and treat their data incorrectly. In this paper I will try to compare generalised logistic curves with simple ones and explain their characteristics, so as to help students and researchers avoid mistakes.

Tae Rim LEE, Department of Applied Statistics, Korea National Open University, Seoul, Korea, *Teaching biostatistics for medical personnel with computer based supplement.* There is in creasing need for medical personnel and health care professionals to use statistics in their master's thesis or other research. Today, statistical analysis can be easily performed using a statistical package. This access increases the requirement for a biostatistical understanding among health professionals in order to choose the appropriate statistical method and to interpret the result obtained by the computer. Many medical journals as well now require a high level of statistical sophistication from their authors. There is an increasing awareness among biostatisticians of the importance of understanding the methodological issues that underlie the statistical approaches used in medical research. In Korea, statistics courses using more flexible modes and newer technologies such as the w.w.w., CD titles and cable television programs are being offered. Resent developments in technology can potentially lead to great improvements in teaching statistics. A computer based learning of statistics has attracted particular attention from both the students and researchers. This paper outlines a flexible teaching methods of biostatistics along with various kinds of supplementary materials(diskettes, video and w.w.w.).

Dalene STANGL, Duke University, Institute of Statistics and Decision Sciences Durham, NC USA. *Design of an Internet course for training medical researchers in Bayesian statistical methods.* Access to statistical information is at an all-time high, and the information age is fueling this access at an extraordinary pace. This access increases the capacity for medical researchers to use statistics to guide decision making, yet few courses teach methods to do so. Rarely does statistics training include methods for incorporating statistical output into decision making. No question, mass education and educational reform are needed. Technological advances of the past decade make both goals possible. These advances can dramatically change how we use, teach, and think about statistics. This paper covers the conceptual development of an Internet continuing-education course designed to teach the basics of the Bayesian statistical paradigm to medical researchers. Special attention is given to 2 questions: Why internet-based instruction, and why the Bayesian paradigm?

Gianfranco GALMACCI, Dipartimento di Scienze Statistiche, Universita' degli Studi, Perugia, Italy. *The impact of the Internet on researchers' training.* The Internet can be considered the biggest Data Base ever built and it grows day by day. The information spreads out in all directions and is available in real time. Today we can say that there is no scientific field that has not yet been influenced in some way by network facilities. Sometimes the benefits may simply be more a powerful way of communicating and cancelling distances. Sometimes there are many more important advantages, depending on the specific field. The role of researchers is so critical that their training always requires careful attention, especially when events can so profoundly modify working methods and procedures. The aim of this paper is to analyse in detail all the various aspects, presented above, to outline a profile of the current trends and to stimulate discussion on this matter.

3. Needs and problems in training researchers in specific areas

Session 3.1. Discussion: *Gilberte SCHUYTEN,* Department of Data Analysis, University of Gent, Belgium

John Harraway, Bryan MANLY, Hilary Sutherland and Allan McRae. Department of Mathematics and Statistics, University of Otago, New Zealand. *Meeting the statistical needs of researchers in the biological and health sciences.* The results of a survey on the use of statistics in research in several subject areas representative of the biological and health sciences are reported. The main component of the survey is a review of statistical methods in 2927 research papers published last year in 16 high impact journals from botany, ecology, food science, marine science and nutrition. It is established that research papers in the different subject areas use different methods. The opinions of research staff and postgraduate students working in these areas are also reported. To support these opinions we provide details of five postgraduate studies involving advanced statistical analyses which have either resulted in publication or should result in publication in the near future. Discussion develops recommendations about topics important in a statistics curriculum for research students, where statistics courses should be taught, what is needed in terms of level of theory, the use of short courses and workshops, and the value of project work.

David J. Saville, Canterbury Agriculture and Science Centre, Lincoln, New Zealand. *Ahands-on, interactive method of teaching statistics to agricultural researchers.* In this paper I focus on two topics. The first topic is several day-long workshops which I run annually for agricultural researchers. These cover the "linear model" methods, based upon the normal distribution, which are very commonly used by agricultural researchers. These methods are analysis of variance, regression and analysis of covariance. I describe the manner in which these workshops are run, cover the content of the workshops, describe the course evaluations, speculate upon why the workshops have proven to be popular, and attempt to draw conclusions. The second topic is a method of teaching linear model theory using N-dimensional geometry This method has been successfully used for both second-year and graduate-level university statistics courses.

Glenys BISHOP, Statistical Services Branch, Australian Bureau of Statistics Australia, & Mike Talbot, BioSS, Edinburgh, United Kingdom: *Statistical thinking for novice researchers in the biological sciences.* Postgraduate students from non-statistical disciplines often have trouble designing their first experiment, survey or observational study, particularly if their supervisor does not have a statistical background either. Such students often present their results to a statistical consultant hoping that a suitable analysis will rescue a poorly designed study. Unfortunately it is often too late by that stage. A statistical consultant is best able to help a student who has some grasp of Statistics. It is appropriate to use the Web to deliver training when required and that is the mechanism used in this project to encourage postgraduate students to develop statistical thinking in their research. Statistical Thinking is taught in terms of the PPDSA cycle and students are encouraged to use other Web resources and books to expand their knowledge of statistical concepts and techniques.

Session 3.2. Discussion: *Brian PHILLIPS,* Swinburne University of Technology, Australia

Carol Joyce BLUMBERG, Dept. of Mathematics and Statistics, Winona State University, USA. *Training regular education and special education teachers in the use of statistics.* The purpose of this paper will be to discuss that needs of Special Education teachers in terms of knowledge and use of statistical methodology. In the USA the term Special Education teacher refers to any teacher who has taken extra training (usually as part of a first degree) to be able to teach students with disabilities such as mental retardation (the exact term used actually varies from state to state in the USA), learning disabilities, emotional problems, and physical disabilities. The paper itself will be split into two parts. The first part will deal with the needs in terms of statistical methodology of all teachers who are completing a course in research methods and/or statistics. The second part of the paper will deal with the needs that are specific to Special Education teachers.

Michael GLENCROSS and Andile Mji, Research Resource Centre, University of Transkei, Umtata, South Africa. *The role of a research resource centre in the training of social science researchers* At the University of Transkei teaching and research are considered to be two sides of the same coin. Research is thus regarded as a fundamental and indispensable activity. With the University facing the challenge of becoming competitive within the new structure of higher education in South Africa, a strategic plan for research in the Humanities and Social Sciences has resulted in a flexible blueprint for research development. The Research Resource Centre supports this initiative by facilitating research capacity development and research excellence within the University. This paper discusses the role of the Research Resource Centre in the provision of research training for social science researchers and provides details

of the various workshops and seminars used to develop skills in the use of statistics and computer-based statistical packages.

4. International experiences in the training of researchers. <u>Discussion:</u> *M. Gabriella Ottaviani,* Universita' di Roma "La Sapienza", Italy

Shrikant I. Bangdiwala, and Sergio Muñoz, University of North Carolina, School of Public Health, USA. *Training of statisticians world-wide to collaborate as co-investigators within country clinical epidemilogy units: The experience of the International Clinical Epidemiology Network (INCLEN).* Clinical researchers rely on biostatisticians in order to design, conduct and analyse observational and experimental studies involving populations of subjects. In many countries, trained biostatisticians are not readily available. There are many possible approaches to this problem, including educating the medical professional to be a researcher with an understanding of statistical methodologies, as well as training statisticians to be biostatisticians with an understanding of clinical considerations. The International Clinical Epidemiology Network (INCLEN) embarked on such an endeavour by creating clinical epidemiology units that included both approaches, trained clinical epidemiologists as well as biostatisticians. The specific statistical training needs of both types of students are described.

Eduardo CRIVISQUI, Stefano ABRUZZINI, Laboratoire de Méthodologie du Traitement des Données, Bruxelles, Belgium, and Carlos Marcos Batista, Universidade Goia, Brazil. *How to fill the gap between the available statistics methods and their effective and potential users. Some reflections from the experience of the PRESTA programme.* The PRESTA programme is a training programme in applied statistics which started in 1994. The main beneficiaries of the programme were teachers and investigators of South American universities, but also professionals in charge of studies of public and non-governmental centres of these countries. The programme, backed by the European Union, proposed to spread on a large scale an exploratory approach of statistical methods for a « critical mass » of users. Having reached the end of its first quinquenial period, the programme has carried out some 6000 training hours through a hundred seminars attended by 3000 investigators and teachers from about 300 universities, investigation institutions and public administrations of South America. We discuss our experience, main problems, didactic strategies and plans for continuation.

David OSPINA, and Jorge E. Ortiz, Department of Statistics, Universidad Nacional de Colombia, Santa Fe de Bogotá, Colombia: *Statistical research and consulting in universities from developing countries: the Colombian case.* This paper focuses on describing the experience of statistical researchers and consultants of the Statistics Department, faculty and students, and of researchers who are not statisticians, at the Universidad Nacional de Colombia. An analysis is made of the statistics programs of study including consulting activities, and of three surveys that were designed, distributed and analysed: one for the newly graduated and senior year students concerning their training in research and consulting during their studies; a second one for statistics staff at the Department and a third for non-statistician researchers at the University who usually have to deal with statistical methods. A study is made of the main problems in the formation and training of students as statistical researchers and consultants, as well as the difficulties of the experienced researchers and consultants. Recommendations to improve the actual situation are proposed.

Yuan Wei, Renmin University of China, Beijing, China. *The training of researchers in the use of statistics in China.* The responsibility of training researchers in the use of statistics in China belongs to colleges, universities and research institutes. There is a National Statistical Education Association. Under the Association, the Higher Education Branch is an organisation of colleges, universities and research institutes who have the statistical major or the statistical faculty. Since China has 1.25 billion population and more than 100 thousand official statistical staffs in the whole country, the statistics training is a huge work. There are degree study and non-degree training programs. In the degree study, there are undergraduate program (colleges and universities) and graduate program (colleges, universities and research institutes). In the non-degree training, the different training programs have been used. Statistical methods are widely used in almost all fields. The most important application areas are: the official statistical work including sapling survey and processing the data, micro-economic analysis, management and quality improvement, medical application, agriculture and industry experiment, etc. The researchers in above fields are mostly needed to be trained. Many patterns have been used in training. In class teaching, group discussion, field training, TV, broadcasting programs and Internet are main patterns.

5. Consultation as a teaching and learning process. <u>Discussion:</u> *Yuki Miura*, Faculty of Economics, Surugadai University, Japan

Gabriella BELLI, Virginia Polytechnic Institute & State University, USA, *The teaching/ learning process in University statistical consulting labs in the United States.* The main focus of this paper is on how statistics students are trained in consultancy skills, as well as on how faculty in charge of university statistical consulting units perceive the consultant's role in training researchers. An electronic survey of 106 USA departments was conducted. Results indicate a wide range of practices in how students consult and how they are trained in consulting skills, but much greater consistency in the belief that such training is essential to a statistician's education and about the problems faced by both student consultants and student clients. The consulting service was seen as a useful way for researchers to learn because they would be working on a problem or data set of interest to them. Respondents discussed the importance of collaboration, particularly as a goal for consulting relationships that would benefit both parties, with reciprocal teaching and learning.

Juan D. GODINO, Carmen BATANERO, and Ramón G. Jaimez, Department of Mathematics Education and Department of Statistics, University of Granada, Spain. *the statistical consultancy workshop as a pedagogical tool.* In this article we present and analyse the results of three related experimental studies: (1) the use of statistics in a sample of mathematics education doctoral theses in Spain; (2) the attitudes towards data analysis and statistical consultancy by doctoral students in education; (3) the future statistics consultants perception of their competence for consultancy work. We also describe a project aimed to implement two didactical devices, which would improve the researchers' attitudes and use of statistics and the future consultants' competence. This project would serve to link together prospective consultants and clients within a Statistical Consultancy Unit at the Faculty of Education.

Flavia JOLLIFFE, School of Computing and Mathematical Sciences, University of Greenwich UK, *Learning from experience.* Training courses for researchers are discussed in some detail. The preparation of researchers and of statisticians for consulting sessions, and the opportunities such sessions provide for training, are considered.

Ben-Chang Shia, Department of Statistics, Fu Jen Catholic University, Taipei, Taiwan, China. *How to think about statistical consultation. Learning from data.* The purpose of this paper is to expand statistics science. To begin with, I will talk about the present status of statistics education and its importance. Then I will discuss the seven main statistical topics: 'Descriptive statistics', 'Basic concepts', 'Statistical process control', 'Random walks', 'Introduction to statistical tools', ' How to do data analysis' and ' How to consult'. And with the expansion and development of IT and Internet, it is the e-century now, so statistics education should be different. Finally I suggest the idea of "statistical electronic school (statistical e-school)".

Closing: Brian PHILLIPS, and Carmen BATANERO, International Association for Statistical Education, and Yuki Miura, Japan Statistical Society.

11.7. XXVIII Statistical Education Activities at the Coloquio Argentino de Estadística, Posadas, Misiones, Argentina August 8-11.

Ana Silvia HAEDO

There was a Section devoted to the teaching of statistics at the XVVIII Conference of Statistics in Argentina, as a contribution of the *SAE* (Argentina Statistical Society) to improving the teaching of statistics at the different educational levels.

Professor Samprit Chatterjee (N.Y. University, USA) discussed "Teaching Statistics Effectively" , and his ideas attracted wide interest in the audience.

At the Opening an hommage was paid to Professor Carlos E. Dieulefait, who was born 100 years ago and was one of the founders of the School of Statistics in Rosario, and the Argentina Statistical Society.

A full one-day course on "chance and simulation" was given by Daniel Vazquez Vargas and co-ordinated by Ana Silvia HAEDO.

Papers presented:

- GALLESE, E, MALVICINI, S., & Reinoso, A. *La economía intangible y la enseñanza de la estadística* [The hidden economy and the teaching of statistics].

- Antonio, J., Alvarez, M., De giorgio, N., FERRERI, N, & Molina, G. Panzeri A. *Técnica de casos: Una herramienta para investigar en educación estadística* [Case studies: A tool for research in statistics education].

- FERRERI, N., & GALLESE, E. *El curso de estadística para alumnos de carreras no estadísticas* [Statistics course for students taking non-statistics majors].

- Koatz, V., & Prado, N. *El saber estadístico: necesidad de su abordaje en la formación de docentes investigadores* [Statistics knowledge: the need to take it into account in training teacher-researchers].

- Curti, C., & Rosa, E. A. *Las aplicaciones de los métodos estadísticos a problemas reales en la enseñanza estadística de grado* [The application of statistical methods to real problems in teaching undergraduate statistics].

- MEYER, R., & Debiaggi, M. B. *Significado de la normalidad en investigadores. La práctica estadística en educación* [The meaning of normality for researchers. The practice of statistics in education].

- Camargo, M.E. *Aprendendo estatística no ensino fundamental* [Learning statistics at compulsory education].

- GALLESE, E., Anido, M. & LAC, PRUGENT N. M. *Mercado laboral, computación y pegagogía* [Labour markets, computation and education].

Posters:

- Romero, G., Aparicio, S., & Rada, A. Contreras, N. *Parcial domiciliario: Una propuesta innovadora de evaluación en la enseñanza de bioestadística* [Take-home assessment: An innovative proposal for assesment in the teaching of biostatistics].

- Romero, G., Aparicio, S., Rada, A., & Contreras, N. *Bioestadística I y ciencias sociales I de la carrera de enfermería. Una buena sociedad para el año 2000* [Biostatistics I and Social Sciences I in nursing training. A good society for the 2000].

- Rodríguez, M. I., Palacio, G., Herrera, M. I., & Barberis, P. *Enseñanza de la estadística interactuando con la computadora* [Teaching statistics with computer interaction].

- Recchioni, L., Tineo, J., Fonseca, C., & Mércoli, I. *Análisis multivariado de indicadores educativos del nivel EGB según el SIPESCE. Provincia de la RIOJA* [Multivariate analysis of educational indicators of EGB level acording SIPESCE. RIOJA district]

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12. Fortcoming Conferences

12.1. *ICOTS-6* Call for Papers

The Sixth International Conference on Teaching Statistics
Durban, South Africa,7 - 12 July 2002
IPC Website: http://www.beeri.org.il/icots6
LOC Website: http://icots.itikzn.co.za/

The International Association for Statistical Education (IASE) and the International Statistical Institute (ISI) are organizing the Sixth International Conference on Teaching Statistics (ICOTS-6) which will be hosted by the South African Statistical Association (SASA) at the International Convention Centre in Durban from July 7 - 12, 2002.The major aim of ICOTS-6 is to provide the opportunity for people from around the world who are involved in statistics education to exchange ideas and experiences, to discuss the latest development in teaching statistics and to expand their network of statistical educators. The Conference will include keynote speakers, invited speakers, contributed papers, workshops and forums, demonstration lessons, roundtable sessions, poster sessions, book and software displays, hands-on computer sessions and many opportunities for the communication and exchange of experiences and ideas.

As the Conference theme for ICOTS-6 is "Developing a Statistically Literate Society", special sessions on statistical literacy are planned. These will include keynote presentations on statistical literacy and sessions and discussions of the role of statistics in a number of everyday contexts.

The scientific programme of the Conference has been prepared by the IASE International Programme Committee, IPC, for ICOTS-6 on the basis of suggestions received from many members. The IPC is in charge of the overall co-ordination of the scientific programme. The IPC has agreed on a list of topics for the invited paper sessions, and identified Topic Convenors who in turn suggested Session Organizers, SO's, for approval of the IPC. The SO's will assume responsibility for the organization of each invited paper session. The topics of invited paper sessions and the SO's names and addresses are now available on the ICOTS-6 IPC Website at http://www.beeri.org.il/icots6/. The Rules and Guidelines for Organisers of invited paper sessions will be available in the IPC Website by the end of September 2000.

After extensive discussions, the IPC have regretfully come to the decision, that refereeing procedures will not be implemented in ICOTS-6. If requested, the IASE is normally happy to give permission for authors to submit their papers (or a more comprehensive version) to other journals. If this occurs the author must seek approval of the editor of the ICOTS-6 Proceedings and the IASE President, and the paper is to have an acknowledgement saying "This article was written for, and published in, the ICOTS-6 Proceedings and is reprinted (in revised form, *if relevant*) here with the permission of the IASE."

Important deadlines:

Invited papers

- *Expression of interest* for invited sessions are to be received by the relevant Session Organizer, or the IPC Chair by Oct. 15, 2000.

- *Invitations:* Session Organizers will formally invite the speakers by Jan 31, 2001.

- *Abstracts* - each invited speaker has to present a (provisional) title and an abstract (no more than 500 words) of his/her presentation to their Session Organizer by April 1st, 2001.

- *Final manuscript* - the authors of invited papers are to submit the final manuscript of their paper to their Session Organizer by December 1st, 2001.

Contributed papers

- *Expression of interest* for contributed paper sessions are to be submitted to Susan Starkings (starkisa@sbu.ac.uk) by December 1st, 2001. Papers not accepted for an invited speaker session will also be considered for the contributed paper sessions.

Other presentations

- Abstracts of posters, software demonstration and other special sessions should be submitted to the IPC Executive by February 1st, 2002.

ICOTS 6 Topic and Session List

Topic 1. Statistical Literacy Sessions. Convenors: Brian PHILLIPS (Australia), <bphillips@groupwise.swin.edu.au> and Iddo Gal (Israel), <iddo@research.haifa.ac.il>.

Topic 2. Statistical Education at the School Level. Convenor: Lionel PEREIRA MENDOZA (Singapore), <lpereira@nie.edu.sg>.

    2A. Innovative Ideas for Teaching Statistics in Elementary School, Dave Pratt (UK), <dave.pratt@warwick.ac.uk>;

    2B. Innovative Ideas for Teaching Statistics in Secondary School, Gail BURRILL (USA), <gburrill@macc.wisc.edu>;

    2C. Research on Teaching Statistics at the School level, Jane WATSON (Australia), <Jane.Watson@utas.edu.au>;

    2D. Innovative Ideas on Assessment of Statistics - Lessons from Research, To be announced

    2E. Innovative Statistics Curriculum Development and Research Projects at the School Level, Dani BEN-ZVI (Israel), <dani.ben-zvi@weizmann.ac.il>;

    2F. Socio-Cultural Aspects in the Learning of Statistics at the School Level, Paul Cobb (USA), <paul.cobb@vanderbilt.edu>;

    2G. Local Teachers Sessions, Vishnu Naidoo (South Africa), <vishnu@yebo.co.za>.

Topic 3. Statistical Education at the Post Secondary Level. Convenor: Gilberte SCHUYTEN (Belgium), <Gilberte.Schuyten@rug.ac.be> and Allan ROSSMAN (USA), <rossman@dickinson.edu>.

    3A. Statistics as a Service Subject in First Level Courses, Beth CHANCE (USA), <bchance@calpoly.edu>;

    3B. Statistics as a Service Subject in Second Level Courses, Joachim ENGEL (Germany), <engel_joachim@ph-ludwigsburg.de>;

    3C. Statistics for Future Statisticians, Ann Cannon (USA), <ACannon@cornell-iowa.edu> and Takashi Yanagawa (Japan), <yanagawa@math.kyushu-u.ac.jp>;

    3D. Statistics and Research Designs: An Integrated Approach,To be announced;

    3E. Statistics Learning with Cases/Projects, Roxy PECK (USA), <rpeck@calpoly.edu>;

    3F. Bayesian Statistics, Dalene STANGL (USA), <dalene@stat.duke.edu>;

    3G. Nonparametric Methods,To be announced;

    3H. Statistics to Teach Consulting Skills, Gabriella M. BELLI (USA), <gbelli@vt.edu>;

    3I. Statistics for Future Teachers, Zakayo Msokwa (Tanzania), <Msokwa@ucc.udsm.ac.tz>;

    3J. Statistics for Future Health Care Professionals, Tom SHORT (USA), <thomas.short@villanova.edu>;

    3K. Sampling for Surveys, Alan Welsh (Australia), <Alan.Welsh@anu.edu.au>;

    3L. Multi-variate Statistics, John Harraway (NZ), <jharraway@maths.otago.ac.nz>;

    3M. Hypothesis Testing, Alan MCLEAN (Australia), <alan.mclean@buseco.monash.edu.au>;

    3N. Teaching Categorical Data Analysis, Michael Campbell (U.K.), <M.J.Campbell@sheffield.ac.uk>.

Topic 4. Statistical Education/Training and the Workplace. Convenor: Carol Joyce BLUMBERG (USA), <cblumberg@winona.edu> and René H. M. SMULDERS (The Netherlands), <RSLS@cbs.nl>.

    4A. Making Statistical Consulting and Technical Co-operation More Effective, Jean-Louis BODIN (France), <jean-louis.bodin@wanadoo.fr>;

4B. The Role of National and International Statistics Organizations in Improving Statistical Knowledge in the Workplace, Marcel Van den Broecke (The Netherlands), <isi@cbs.nl>;

4C. Training of Official Statisticians, Denis Farrell (Australia), <denis.farrell@abs.gov.au>;

4D. Distance Learning, Lea BREGAR (Slovenia), <lea.bregar@uni-lj.si>, Irena OGRAJENSEK (Slovenia), <irena.ograjensek@uni-lj.si>, and Bettie Basson (South Africa), <bsson-em@marlin.vista.ac.za>.

4E. Using Official Statistics for Teaching, Sharleen FORBES (New Zealand), <Sharleen_Forbes@stats.gov.nz>;

4F. Statistical Training and Education of Lawyers, Judges, Doctors, Researchers, and Other Professionals, Elisabeth SVENSSON (Sweden), <eliss@math.chalmers.se>; Kamanzi-wa Binyavanga (South Africa), <kamanzi@getafix.utr.ac.za>;

4G. Preparation and Training of Workers in the 21st Century, Albert P. SHULTE (USA), <Al.Shulte@oakland.k12.mi.us>;

4H. Educating Managers, Executives, Politicians, Government Officials and Other Decision Makers, C. L. Kincannon (USA), <clkincan@hotmail.com>;

4I. Statistical Training and Education in Environmental Settings, Carmen CAPILLA (Spain), <ccapilla@eio.upv.es>;

4J. Practical Training in the Workplace for Tertiary and Postgraduate Students, Katherine TAYLOR HALVORSEN (USA), <khalvors@science.smith.edu>;

4K. Training of Institutional Research Professionals, Amanda Lourens (South Africa), <Amanda@Techpta.ac.za>;

4L. Informal Gathering of Those Interested in Statistics Education/Training in the Workplace, Carol Joyce BLUMBERG (USA), <wncarolj@vax2.winona.msus.edu> and René H.M. SMULDERS (The Netherlands), <RSLS@cbs.nl>.

Topic 5. Statistical Education and the Wider Society. Convenor: Helen MACGILLIVRAY (Australia), <h.macgillivray@fsc.qut.edu.au>.

5A. Relationships with Mathematical Education, To be announced;

5B. Teaching Statistical Thinking for Use in the Wider Society, To be announced;

5C. Statistical Education in and for the Economic World of Business and Government, Eric SOWEY (Australia), <e.sowey@unsw.edu.au>;

5D. Statistical Education and the Statistical Profession, Neville DAVIES (UK), <neville.davies@ntu.ac.uk>;

5E. Statistical Education and the Engineering World, Helen MACGILLIVRAY (Australia), <h.macgillivray@fsc.qut.edu.au>;

5F. Statistical Education and the World of Information Technology, Gianfranco GALMACCI (Italy), <glm@stat.unipg.it>;

5G. Statistical Education and the World of Life and Health Sciences, Petter LAAKE (Norway), <petter.laake@basalmed.uio.no>;

5H. Incorporating Social Issues, Jacky Galpin (South Africa), <jacky@galpin.co.za>.

Topic 6. Research in Statistical Education. Convenors: CARMEN BATANERO (Spain), <batanero@ugr.es>, and Joan GARFIELD (USA), <jbg@tc.umn.edu>.

6A. Developing Statistical Education Research, Mike SHAUGHNESSY (USA), <mike@mth.pdx.edu>;

6B. Theoretical Models of Statistical Knowledge, Thinking, Reasoning and Learning, Maxine PFANNKUCH (NZ), <pfannkuc@scitec.auckland.ac.nz>, and Chris WILD (NZ), <Wild@stat.auckland.ac.nz>;

6C. Technology and Research in Teaching and Learning Statistics, Erica MORRIS (UK), <e.j.morris@open.ac.uk>;

6D. Studies of Assessment in Statistical Education, Susanne Lajoie (Canada), <lajoie@education.mcgill.ca>;

6E. Teachers' Training, Conceptions and Beliefs, Lisbeth CORDANI (Brazil), <lisbeth@ime.usp.br>;

6F. Research into Teaching and Learning Statistics at Tertiary Levels, Flavia JOLIFFE (UK), <F.R.Jolliffe@greenwich.ac.uk>;

6G. Research into Teaching Learning Probability, Ana Maria Ojeda (Mexico), <amojeda@yahoo.com>;

6H. Round Table Discussion: Major Problems and Directions in Statistical Education Research, Joan GARFIELD (USA), <jbg@tc.umn.edu> and Carmen BATANERO (Spain), <batanero@ugr.es>;

Topic 7. Technology in Statistics Education. Convenor: Laurence WELDON (Canada), <Weldon@sfu.ca>.

7A. Java-Based Instructional Packages, Doug STIRLING (New Zealand), <d.stirling@massey.ac.nz>;

7B. Computer-Based Demonstrations of Statistical Phenomena, Andrej BLEJEC (Slovenia), <andrej.blejec@uni-lj.si>;

7C. Using Technology for Statistics Education in Engineering, David Bacon (Canada), <david.w.bacon@sympatic0.ca>;

7D. Technology to Facilitate Learning of Statistics (Could split to two sessions, need different titles); Bill FINZER (USA), <bfinzer@keypress.com> and Paul VELLEMAN (USA), <pfv2@cornell.edu>;

7E. The Teaching of Wildlife Statistics or: Internet Based Animations for Teaching Estimation, To be announced;

7F. Designing Software Based on Research of Student Reasoning, Cliff Konold (USA), <konold@srri.umass.edu>;

7G. Software Tools Designed for Statistics Education, To be announced;

7H. Statistics Education and the Internet, Joe WISENBAKER (USA), <joe@coe.uga.edu>;

7I. Using Graphics Calculators in Statistics Education, Kay LIPSON (Australia), <klipson@swin.edu.au>;

Topic 8. Other Determinants and Developments in Statistics Education. Convenor: Philip J. BOLAND (Ireland), <Philip.J.Boland@ucd.ie>.

8A. Learning Factors in Statistical Education, Robert delMas (USA), <delma001@maroon.tc.umn.edu>;

8B. Data Analysis and Statistical Learning, Kay McClain (USA), <mcclaikl@ctrvax.Vanderbilt.Edu>;

8C. History of Stochastics Education, John TRURAN (Australia), <truranjk@camtech.net.au>;

8D. Gender and Cultural Factors in Statistical Education, Rosa Giaimo (Italy), <giaimo@mbox.unipa.it>;

8E. Projects and Poster Competitions in Statistical Education, Jerry MORENO (USA), <moreno@jcvaxa.jcu.edu>;

8F. The Mass Media and Statistics, Shen Shir Ming (China), <smshen@hkuspace.hku.hk>;

8G. Teaching Statistics to Second-Language Students, Mbulaheni Nthangeni (South Africa), <mbulahenin@unin.unorth.ac.za> and Derek Chalton (South Africa), <dchalton@uwc.ac.za>.

Topic 9. An International Perspective on Statistical Education. Convenor: Vitalis MUBA (Tanzania), <eastc@ud.co.tz>.

Sessions organisers: Helena BACELAR-NICOLAU (Portugal), <hbacelar@fc.ul.pt>; Fayez MINA (Egypt), <fmmina@link.com.eg>, Teresita TERAN (Argentina), <teresitateran@hotmail.com>.

Topic 10. Contributed Papers. Convenor: Susan STARKINGS (UK), <starkisa@sbu.ac.uk>

Topic 11. Posters

Details of the final submission arrangements of papers and other presentations will be announced later.The Committee is convinced that the ICOTS-6 academic and social programme will provide a most rewarding experience. For more information please contact the Conference Chair or the IPC Scientific Secretary.

- Maria-Gabriella OTTAVIANI, Chair, <ottavian@pow2.sta.uniroma1.it>

- Dani BEN-ZVI, IPC Scientific Secretary,<dani.ben-zvi@weizmann.ac.il>

12.2. IASE Satellite Conference on Statistical Literacy

IASE Satellite Conference on Statistical Literacy
Seoul, Korea, 21-22 August, 2000
http://www.swin.edu.au/maths/iase/statlit.html

First Announcement and Call for Presenters

This satellite conference on statistical literacy is jointly organised by the IASE and the Korean Statistical Society and will immediately precede the ISI session in Seoul. It will give the opportunity for people to enjoy presentations given by people who have a special interest in statistical literacy. There will be a number of invited speakers, as well as the opportunity for others to give contributed presentations.The presentations are planned to include discussions of the main components in statistical literacy and the relevance of statistical literacy in the general education of citizens.

The approach will be non-technical, suitable for a non-specialist audience who would like to learn how to make better use of probability and statistical ideas in their everyday and working lives in areas in which chance and risk is involved. This meeting is intended to be of interest to a wide cross section of society including teachers, educational administrators, researchers in statistical education and in probabilistic reasoning and others who want to gain a better grasp of statistics in general and who would like to broaden their knowledge of statistics applications. It should also be of interest to people wishing to understand more about risk in making investments and gambling, by those concerned with interpreting sociological, economical, political, scientific or educational reports, predicting sports results, by policy makers, journalists, health professionals and others from the general population.

Location: Convention and Exhibition Center (COEX), Seoul, Korea

Program times:

Tuesday August 21:   9.00 am - 5.30 pm, Conference Dinner: 7.30 pm

Wednesday August 22:   9.00 am - 12.30 pm

Programme committee:

Brian PHILLIPS (Australia) (Chair), Yong Goo Lee, (Korea) (Local organiser)

Tae Rim LEE (Korea), Carmen BATANERO (Spain), Larry WELDON (Canada)

Abstracts: (300-400 words, in ASCII or rtf format) of proposed presentations should be submitted to the program chair as early as possible, but no later than November 31, 2000. They should include full information on the authors and their affiliations, and the contact address (including e-mail and fax). Earlier

submissions are encouraged as there will be a very limited number of presenters. Acceptance is conditional on the attendance at the meeting by the author.

Important dates:

Abstract deadline: November 31, 2000.

Paper acceptance: December 31, 2000.

Submission of final papers: May 19, 2001.

More information: See web page: http://www.swin.edu.au/maths/iase/statlit.html

Contacts:

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Brian PHILLIPS, School of Mathematical Sciences, Swinburne University of Technology, PO Box, 218, Australia, 3122, Phone: +61 3 9214 8288, Fax: +61 3 9819 0821, E-mail: bphillips@swin.edu.au

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12.3. Other conferences

"Statistical Education at the Beginning of the Millennium", 20 September 2000

To be held in conjunction with the *Royal Statistical Society Education Section* at 12 Errol St., London, Wednesday 20 September 2000, this conference is jointly endorsed by ISI and the IASE.

Program:

- Mike FULLER, Canterbury Business School, University of Kent: *Statistics Education and ICT: Visual, Informed, Practical*

- Peter HOLMES, RSS Centre for Statistical Education, Nottingham Trent University: *Some Current Issues in Undergraduate Statistics Teaching*

- Kevin MCCONWAY, Department of Statistics, The Open University:*What Do Statistics Students Really Want? Students' Feedback at the Open University*

- Philip Male, SASInstitute: *SAS 8e - Internet Enabled Analytical Software*

- Deborah Ashby, Royal London School of Medicine and Dentistry, and at Queen Mary and Westfield College: *Recent Developments in Evidence- Based Medicine: Opportunities for Teaching Statistics*

- Flavia JOLLIFFE, University of Greenwich, and Chair of RSS Education Section: *Training Researchers in the Use of Statistics*

- Darren Short, Office for National Statistics: *Statistics and Learning Transfer: Helping Students Transfer Their Learning from the University to the Workplace*

Conference Organiser and Chairman: Dr Nasrollah Saebi, Email: <MA_S416@kingston.ac.uk>

XXVII Jornadas Nacionales de Estadistica, Valdivia, Chile, 9-11 Octubre 2000

The Institute of Statistics, at the Universidad Austral, Chile and the Sociedad Chilena de Estadística (SOCHE), are organising their 27th Conference to be held Universidad Austral de Chile. Main aims are to illustrate relevant aspects in the recent development of theoretical and practical statistics, stimulate the exchange

among users of new techniques and applications in different disciplines and stimulate the development of the discipline. More information in available at http://smtp.uach.cl/infgen/eventos/jnestadistica/. Conference themes are:

- Statistics and science: Theoretical and methodological facets of statistics in different disciplines;

- Statistics and business: Utility of statistical methods and tools as a support to organisational management;

- Statistics and Education: Giving priority to methodological aspects in the teaching of statistics and the role of statistics in evaluating the University teaching;

- Statistics and Economy: The business role on economy and regional economy.

Stochastics Section of German Mathematics Education Association: Autumn Conference 2000, Berlin November, 10–12, 2000

This conference is jointly organised by the Gesellschaft für Didaktik der Mathematik and the Max-Planck-Institute for Human Development, and it is centred on the NCTM-Standards: Impulses for Improving Stochastics Instruction. Preliminary programme include:

- Prof. Dr. Jürgen Baumert (Max-Planck-Institute). *Consequences of the TIMS-study for high school mathematics instruction*

- Prof. Dr. Rolf BIEHLER (University of Kassel). *The North-Rhine-Westphalia-curriculum: statistics in grade 11*

- Dr. Joachim ENGEL (PH Ludwigsburg). *The NCTM Standards and the Quantitative Literacy Project*

- Prof. Gerd Gigerenzer (Max-Planck-Institute). *Statistical thinking or statistical rituals: what students need*

- Dr. Laura Martignon (Max-Planck-Institut). *Representation of information in probability*

- Dr. Peter Sedlmeier (University of Paderborn). *Statistics without formula*

Updated information available from Manfred Borovcnik and Joachim ENGEL, Institut für Mathematik und Informatik email: ak-stochastik@ph-ludwigsburg.de or on the homepage of AK Stochastik in der Schüle: www.math-tu-dresden.de/did/stoch/

TIME 2000 - An International Conference on Technology in Mathematics Education
December 11-14th, 2000, Auckland, New Zealand

TIME 2000 will focus upon the uses of technology in, but not limited to, the following areas of mathematics and statistics: Teaching, Learning, Assessment, Distance education, Research, Teacher development, Problem solving, Curriculum, Web-based resources. This conference will serve as a forum to discuss, present, explore and exchange information in mathematics and statistics education using: presented papers, hands-on workshop sessions, panel/group discussions, special interest networking sessions, displays of books, materials and technologies. Sessions will cover a broad range of topics, both theoretical and practical, relevant to educators at all levels. It is anticipated that one day will be particularly relevant to schools. The proceedings of the 2000 conference will contain two sections: (i) a refereed section; (ii) other papers submitted but not refereed. All accepted proposals and descriptions of workshops etc. will be published on the conference web page and in the conference pack given to all participants on registration. Please check our website for more information: http://www.math.auckland.ac.nz/TIME2000

International Conference on Recent Developments in Statistics and Probability and Their Applications, India International Centre, New Delhi, India, 30 December–3 January 2001

This International Indian Statistical Association (IISA) Biannual Conference is organised by IISA India Chapter in collaboration with other Indian organisations. Information: Kanwar Sen, Department of Statistics, University of Delhi, Delhi 110007, India. E-mail: <dustats@del3.vsnl.net.in>. Web site: http://www.stat.ohio–state.edu/~hnn/IISA.html

7th Islamic Countries Conference on Statistical Sciences: "Challenges of the 21st Century", January 2-5, 2001, Lahore, Pakistan

The 7th Islamic Countries Conference on Statistical Sciences is organized by the Islamic Society of Statistical Sciences (ISOSS) and The University of Lahore. The Islamic Society of Statistical Sciences (ISOSS) was established during the First Islamic Countries Conference on Statistical Sciences (ICCS-I) held at Lahore on August 27-31, 1988 with the following main objectives:

- Bring together research workers and practitioners in statistical sciences from all over the world and in particular from Islamic Countries through mutual exchange program,

- organize and strengthen a statistical information system,

- promote the application of statistical sciences including computer and information technology in the development of Islamic Countries,

- promote the use of computer technology, robotics and artificial intelligence in Islamic Countries,

- establish training centres to promote statistical education,

- coordinate and unify courses in statistics at all levels of education in the Islamic Countries,

- organize conferences, seminars, colloquia, workshops, short courses, and any other means of communication helpful in exchanging scientific ideas.

Since its establishment the Society has been regularly organizing biennial conferences in collaboration with educational institutions/universities in various Islamic Countries. Contributed papers related to any theory and applied work in the areas of Statistical Sciences, Management Sciences, Information Technology & Software Engineering, Public Health and Health Sciences, Statistics Education, Pharmacy, Crimnometrics and Population Studies are welcome.

Topics for statistics education. Postgraduate Training of Statisticians, Statistical Education in Islamic Countries, Teaching of Statistics at School, Undergraduate and Graduate levels, Technology and Statistical Education, The Future of Statistical Education Research, The Statistical Profession, Present and Future, Statistical Education in Non-Statistics Degree Programs

Conference Secretariat: Faculty of Mathematical Sciences, The University of Lahore, 1-K.M. Raiwind,Lahore, Pakistan, Tel:+92-42-5411901/5411905/5411917/5411986, Fax:+92-42-5413036, Email: <drmunir@brain.net.pk>

CASTME - UNESCO - HBCSE, Goa, India, February 20 - 23, 2001 International Conference on Science, Technology & Mathematics Education for Human Development

This international conference is being organised by the Commonwealth Association of Science, Technology and Mathematics Educators (CASTME) and United Nations Educational, Scientific and Cultural Organisation (UNESCO) through its Project 2000+ in collaboration with the Homi Bhabha Centre for Science Education (HBCSE), TIFR, Mumbai. The conference will focus on Scientific and Technological Literacy (STL) under the broad theme of the role of Science, Technology and Mathematics Education for Human Development. The Conference aims at providing a forum to educational planners, administrators, teacher educators, teachers and researchers in science, technology and mathematics education to exchange ideas on various themesfocussing on the role of science, technology and mathematics education in human development. The Conference will also review achievements of the Project 2000+, a project launched in 1993 by UNESCO and International Council of Associations for Science Education (ICASE), in collaboration with Commonwealth Secretariat, Gender and Science and Technology (GASAT), International Organization for Science and Technology Education (IOSTE), International Council of Scientific Unions (ICSU) and World Council of associations of Technology Education (WOCATE).The conference will deliberate on the following issues:

- Curriculum reforms for human development;
- Assessment and examinations;
- Learner-centered professional staff development;
- Scientific and technological literacy for all including strategies for teaching;
- Popularization, public understanding and life long learning;
- Affordable cost-effective technologies and infrastructure;
- Bridging the gulf between research and classroom practices;
- Empowerment of women;
- Ethics, human rights and culture of peace;

Further information about the conference can be obtained from: Dr. Sudhakar AgarkarHomi Bhabha Centre for Science Education, Tata Institute of Fundamental Research, V.N. Purav Marg, Mankhurd, Mumbai 400 088, INDIA,

E-mail: <sca@hbcse.tifr.res.in>,

Website: http://www.hbcse.tifr.res.in/icstme.html.

CERME 2: Second Conference of the European Society for Research in Mathematics Education, 24th - 27th February 2001 in Mariánské Lázne, Czech Republic

The chief aims of ERME are to promote Communication, Cooperation and Collaboration in Research in Mathematics Education in Europe. Fundamentally we need to know more about the research which has been done and is ongoing, and the research groups and research interests in different European countries. We need to provide opportunities for collaboration in research areas and for inter-European cooperation between researchers in joint research projects. This conference is designed to promote these aims. The conference is designed to foster a communicative spirit. It deliberately and distinctively moves away from research presentations by individuals towards collaborative group work. Its main feature is to be a number of Thematic Groups whose members will work together in a common research area. There are 7 groups in this conference. Researchers wishing to present a paper at the conference should submit the paper to one of these groups.

Working Groups :

1. Building Structures in Mathematical Knowledge
2. Tools and Technologies in Mathematical Didactics
3. Theory and Practice of Teaching from Pre-service to In-service teacher education

4. Social Interactions in Mathematical Learning Situations

5. Mathematical Thinking and Learning as Cognitive Processes

6. Assessment and Curriculum

7. The Role of Metaphors and Images in the Learning and Understanding of Mathematics

If you wish to submit a paper to this conference it should be sent to the group coordinator of ONE of these groups. For details see:http://www.erme.uni-osnabrueck.de/cerme2.htm

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Seattle April 10-14, 2001 *What We Know and How We Know*
82nd Annual Meeting of the American Educational Research Association

Everyone seems to have an opinion about what educational research should and shouldn't do, how it should and shouldn't be done, what counts as 'data' and what doesn't, what is and what is not 'scientific,' and what educational research does and does not say about key topics and issues. For the most part, these discussions, these opinions, these pronouncements are being conducted by nonresearchers and others outside of the arena of educational research. It is time to take back the ball, to weigh in on what we know best, to assume control again of this enterprise within which we work and live.

Within our different research traditions, we have built real bodies of knowledge that inform the educational issues of today. As last year's theme made clear, educational research is being conducted within a range of epistemological perspectives, using diverse methodologies, and addressing different questions. Furthermore, all of this work is viewed, within the different methodological subcommunities that carry it out, as significant to policy and to practice. We do have something to say based on past research results. We need to say it.

Inevitably, as our epistemological presuppositions and methodologies differ, so do our standards for rigor, our perspectives on constructs such as validity and reliability, and the ways in which our results can be generalised and used. What counts as rigor, what counts as evidence, and what is viewed as valid depends on the research tradition and methodology being used. But it is not true that 'anything goes.' Within each tradition there is good, solid research that can be differentiated from poor research. We know this, though we may forget it when thinking of research traditions remote from our own; we suspect that others do not know it and that misinformation is being spread based on this lack of knowledge. Thus, it is time for us to make this clear, to remind ourselves as well as to inform others. We call for penetrating and weighty discussions around issues of research methodologies, rigor, standards -- within every research paradigm.

More information from:

http://www.aera.net/meeting/am2001/call01/index.htm

25th PME conference, 12 - 17 July, 2001, Utrecht, The Netherlands

The conference will be held at Utrecht University, the Netherlands.The conference dates are 12-17 July 2001. The First Announcement will be released in September 2000. Following the PME25 Conference, a Summer School will be organized by the Freudenthal Institute. The dates of the summer school are 18-20 July 2001.

Further information*:* http://www.fi.uu.nl/pme25 or contact Marja van den Heuvel-Panhuizen University of Utrecht, Freudenthal Institute Utrecht, The Netherlands. Email: <m.vandenheuvel@fi.uu.nl>

SRTL-2 The Second International Research Forum on Statistical Reasoning, Thinking, and Literacy, Armidale, Australia, August 15-20, 2001

The second in a series of International Research Forums, being offered under the umbrella of the *Statistical Education Research Group* of the *International Association for Statistical Edu*cation, is to be held in Australia in August 2001. This Forum is sponsored by the Centre for Cognition Research in Learning and Teaching and the School of Curriculum Studies at the University of New England; the International Association for Statistical Education and the University of Minnesota. This gathering offers an opportunity for a small, interdisciplinary group of researchers from around the world to meet for a few days to share their work, discuss important issues, and initiate collaborative projects. The topic of the Forum will be Statistical Reasoning, Thinking and Literacy. One outcome of the Forum will be the publication of a book summarizing the work presented, discussions conducted, and issues emerging from this gathering. Presentations at the SRTL-2 Forum should focus on:

- What does research on SRTL tell us about 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 analyze video material for research on SRTL?

- What are the implications of research into SRTL for learning goals, curriculum design, and assessment?

SRTL-2 Advisory Committee: Dani BEN-ZVI (Weizmann Institute of Science, Israel), Joan Garfield, (University of Minnesota, USA) and Chris Reading (University of New England, Australia) are co-chairs. They will be assisted by Janet Ainley (University of Warwick, UK), Iddo Gal (University of Haifa, Israel), John Pegg (CRiLT Centre, UNE, Australia), and Brian PHILLIPS (Swinburne University of Technology, Australia).

International Statistical Institute, 53rd Biennial Session Seoul, Korea, 22–29 August, 2001

It is a great pleasure for Korean statisticians to host the 53rd Session of the International Statistical Institute(ISI) which will be held in Seoul from 22 to 29 August 2001 under the auspices of the Korean Government and the National Statistical Office (NSO), the Korean Statistical Society and Korean Statistical Association.

The Session will provide a forum for the international exchange of knowledge among participants, and also aims to encourage the international integration of statistics by establishing world-wide relations between the statistical societies and other official and non-official organisations concerned. In addition to being a dynamic forum for scientific and academic exchanges in various fields of statistics, the Session will provide a rare opportunity for all participants to experience the unique Korean culture, history and lifestyle.

The National Organising Committee has the pleasure and honour to invite all members of ISI and its Sections as well as non-members to attend this 53rd Session. In preparation for this conference, arrangements for convenient and comfortable facilities are being made for all participants as well as for a wide variety of social events and cultural tours that will hopefully leave everyone with fond and lasting memories of their visit to Korea.

Again, we are confident that Korea is ready to welcome all visitors from around the world who wish to participate in this first ISI Session of the 21st century. **Information**: ISI Permanent Office, Prinses Beatrixlaan 428, P.O. Box 950, 2270 AZ Voorburg, The Netherlands. Tel.: +31–70–337–5737; Fax: +31–70–386–0025; E-mail: <isi@cbs.nl> *or* visit the Session website at http://www.nso.go.kr/isi2001

IASE Invited Paper Meetings, Seoul, Korea, August 2001

The *IASE* is very pleased to see that the increasing interest in our discipline has lead to an even larger number of statistical education sessions at the 53rd ISI session to be held in Seoul, Korea in August, 2001. There

are seven sessions to be organised by the *IASE* alone, with another four being jointly organised with other sections. Lionel PEREIRA-MENDOZA is co-ordinating our section of the programme. Planning has started and anyone interested in more information should contact Lionel, email: lpereira@nie.edu.sg.

IASE Sessions

1. *Forum: IASE and statistics education in developing countries.* Organiser: Maria-Gabriella OTTAVIANI <ottavian@pow2.sta.uniroma1.it>.

2. *Undergraduate level statistics programmes.* Shen Shir MING <HRNTSSM@hkucc.hku.hk.

3. *The Future of Statistics Education Research.* Joan GARFIELD <jbg@maroon.tc.umn.edu>.

4. *Research on teaching statistics at School and University levels.* Susan STARKINGS <starkisa@vax.sbu.ac.uk>.

5. *Undergraduate statistics education in non-statistics degree programmes.* Elisabeth SVENSSON <eliss@math.chalmers.se>.

6. *Continuing Statistics Education in the Workplace.* Carol BLUMBERG <wncarolj@vax2.winona.msus.edu>.

7. *Postgraduate training of statisticians.* Gilberte SCHUYTEN <Gilberte.schuyten@rug.ac.be>.

Proposed Joint *IASE* Sessions

1. *Women's Contributions to Leadership in Statistical Education,* Joint with CWS. Martha Bilotti-ALIAGA <aliaga@umich.edu>.

2. *Technology in Statistics Education,* Joint with IASC Tae Rim LEE <trlee@av9500.knou.ac.kr>.

3. *The role of official statistics in the university curriculum,* Joint with IAOS. Organiser: Reiner Staeglin, Germany <rstaeglin@diw.de>.

4. *Education and the Internet: Effective Structures,* Joint with IAOS Brian PHILLIPS <bphillips@swin.edu.au>.