NEWSLETTER OF THE INTERNATIONAL STUDY GROUP FOR RESEARCH ON LEARNING PROBABILITY AND STATISTICS

VOLUME 12, NUMBER 3, SEPTEMBER 1999

Secretary and Editor: **Carmen Batanero**

Departamento de Didáctica de las Matemáticas

Facultad de Ciencias de la Educación, Universidad de Granada, Spain

e-mail: batanero@ugr.es http://www.ugr.es/local/batanero/

Associate Editor: **John Truran**

Private Practice

Adelaide, South Australia

e-mail: jtruran@arts.adelaide.edu.au

Table of Contents

1. Notes and Comments: Forthcoming Changes

After our last Newsletter (April 1999), conversations have been maintained with the *IASE* (International Association for Statistical Education) to include our *International Study Group* as a special interest group within this association and to change the Newsletter into a regular *IASE* publication. The IASE is at present the main international association devoted to promoting and extending statistical education through the world at all educational levels. It encourages a variety of different activities directed towards this aim.

There is no doubt that research has a notable influence in extending our knowledge, in advancing the academic recognition of a discipline, as well as in improving the practice of education. For this reason research has been a main interest by *IASE* since its foundation as it is shown in the brief report on the Association's aims and activities below.

The majority of Study Group members are already associated with *IASE*, and the two recent secretaries, Joan and Carmen, are members of the current *IASE* Executive Committee. Moreover, Joan Garfield and M. Gabriella Ottaviani, the 1997-99 IASE president will join the team responsible for producing the Newsletter from January 2000. All of us consider that linking the *Study Group* to *IASE* will benefit the two groups. Receiving information about research activities will be of interest to all *IASE* members, will serve to connect *IASE* researchers to colleagues all around the world, and will allow a quicker spreading of research results that could also benefit curriculum developments. As far as the Study Group is concerned, we believe that *IASE* can provide us with an enormous potential for the development and diffusion of our activities.

We therefore are glad to announce that the Executive Committee has agreed to accept the *International Study Group for Research into Learning Probability and Statistics* as a research group within *IASE*, with the name of *Statistical Education Research Group*. From January 2000 the *Statistical Education Research Newsletter* will replace our current *Newsletter*. It will be published electronically with 3 issues a year, which will be located in a web site linked to the *IASE* main server. All the *IASE* members with e-mail facilities will be sent the table of contents via e-mail.

We encourage those of you who are not members of *IASE* to consider joining this association. A brief summary of its work appears in the next section. However, if you have difficulties joining *IASE* and you are still interested in statistical education research you are invited to remain a member of the new group and to let us know about your future research projects and activities. We finally would like to thank all those who, along the last few years, have sent us information and feedback and thus made this Newsletter possible.

---

2. A Brief History of the Study Group

Until now this has been an informal research network of people who share a common interest in carrying research into the teaching and learning statistics at all age levels. It was at *ICOTS 1* that the idea of forming a study group arose, possibly suggested by Ramesh Kapadia and Anne Hawkins. Efraim Fischbein and David Green drew up a first statement of aims for the group, whose initial name, *International Study Group on Probability and Statistics Concepts and Intuitions,* was slightly changed over the years until the present title was agreed upon. Other people contributing to starting the group were Lennart Råde, Joan Garfield, Hans-Joachim Benz, Ruma Falk, Michael Shaughnessy and Manfred Borovcnic. The first secretary was David Green. In 1988 Joan Garfield took over from David and held office until 1996. During that time Joan increased the group's membership, wrote and distributed the Newsletter, and undertook a review of the group's aims. Carmen Batanero has been the Secretary since 1996.

Aims: In 1988 Joan Garfield published a paper in collaboration with David Green (Teaching Statistics, 1988, 10(2), 55-58), in which they categorised the activities of the group under the following headings:

- promotion of the exchange of information between members;
- encouragement of research activity by members;
- development of instruments by which concepts about probability and statistics could be assessed;
- improvement in the teaching and interpretation of probability and statistics by dissemination of research findings to educators;
- organisation of meetings.

Activities by members: Consequently, our *Study Group* has been an international network of people sharing a common interest in statistical education. They keep in touch through the Newsletter, and the electronic and ordinary mail. At the time being, the group has around 250 members, in the following countries: Argentina, Australia, Austria, Belgium, Brazil, Bulgaria, Canada, Chile, China, Colombia, Cuba, Denmark, Fiji, Finland, France, Germany, Greece, Hungary, India, Israel, Iran, Italy, Japan, Malaysia, Mexico, Netherlands, New Zealand, Norway, Panama, Pakistan, Peru, Poland, Portugal, Romania, Russia, Singapore, South Africa, Spain, Sweden, Turkey, United Kingdom, United States of America, and Venezuela.

Members of the *Study Group* meet at the *International Conferences on Teaching Statistics,* held every four years and at other *ISI* and *IASE* Conferences. In addition there is an increasing group presence in the *Psychology of Mathematics Education Conferences (PME*) and the *PME North American Section* conferences, the *AERA* meetings, and other national and international conferences. Since 1997 a working group has been organised by John and Kath Truran at *PME*, in which different members participate.

Other people have been actively involved in the organisation of *ICOTS, ISI Conferences* and *IASE Round Table Conferences*. There have been contacts among the group members to carry out research projects or to collaborate in the writing of international books. Other activities included applied statistics competition for schools, reporting research results in Journals, such as *Journal of Statistical Education*, or *Teaching Statistics*, doing or supervising dissertations, editing Journals or preparing Internet resources for teaching statistics.

The newsletter: The present newsletter has been edited every three months to serve as a link between members and to provide information useful to research. This newsletter is distributed by e-mail through the *Stat_Ed* list at the University of Granada. It is also available from the web page of the *Statistical Education Research Group* at the University of Granada (http://www.ugr.es /~batanero/).The newsletter contains summaries of research papers written by members, information about members, summaries of recent dissertations, other publication of interest: articles, research reports, books, information concerning recent and forthcoming conferences, and Internet resources of interest.

---

3. The International Association for Statistical Education

The *International Statistical Institute General Assembly* established *the International Association for Statistical Education (IASE)* during the *48th ISI Session* in Cairo, 1991. *IASE* is devoted to the development and improvement of statistical education on a world-wide basis. It has a three-fold role;

- as a professional organisation, providing a forum for those concerned with statistical

education;
- as an organisation for research into statistical education as a discipline in its own right; and
- as the education arm of the *ISI,* taking the lead in, and responding to, issues in statistical education and training, and supporting and promoting statistical education, especially in developing and transition countries.

Its membership mainly comprises those whose interests or professional activities include: teaching statistics at all levels, business and industry training and development, developing software for statistical computing, training statistical staff for government statistical offices, or developing statistical textbooks, audio-visual materials, or curricula.

IASE offers its membership the opportunity to contribute to innovations and progress in statistical education. However, the current *Executive Committee* has recognised, the need to improve channels of communication between statistical educators, who often find themselves relatively isolated in professional terms This is seen as one of *IASE*'s most pressing priorities, along with the need to strengthen support networks in emerging countries.

Several series of conferences are now organised or sponsored by *IASE,* and have been held in venues that are as widely dispersed as possible so that they will be accessible to delegates from many different geographical locations. *IASE* has a commitment to continuing to provide annual international meetings on statistical education. Some of these are satellite conferences, statistical education meetings included within the *ISI Biennial Sessions*, and within the *International Conference on Mathematical Education (ICME)* programmes. But most prominent among the *IASE* conferences are:

International Conferences on Teaching Statistics. *ICOTS* meetings are held every fourth year and cover all aspects of statistical education. They are *IASE's* largest scientific meetings. The fourth conference in this series *(ICOTS 4)* was held in 1994, in Marrakech, Morocco and the fifth in 1998 in Singapore. *ICOTS 6* will be held the 2002 in mid-July in Durban, South Africa.

Round Table Meetings. These are attended by a small, select group of experts in statistical education from various parts of the world. Their purpose is to make recommendations from which institutions and individuals engaged in statistical education and training in developed and developing countries may benefit. Themes of discussion have included "The University Teaching of Statistics in Developing Countries", "New Techniques of Statistical Training", "The Impact of Calculators and Computers on Teaching Statistics", "Training Teachers to Teach Statistics", and "Introducing Data Analysis in Schools. Who Should Teach It and How". The 1996 conference was held in Granada, Spain, on "Research on the Role of Technology in Teaching and Learning Statistics". The next Round Table will be held at the Institute of Mathematical Statistics, Tokyo, Japan in 2000, in connection with ICME9. The theme of the round table will be: "Training Researchers in the Use of Statistics".

More information about the activities of the IASE may be found on its web page located at: http://www.stat.ncsu.edu/info/iase/

---

4. New members

Julio Alvarez Varilla, Manzana 27 lote 3, Barrio Republica de Panamá, Montería, Córdoba, Colombia. email:jalvarez_varilla@hotmail.com

Julio is a teacher interested in statistics. He has contacts with other researchers in statistics and mathematics education in Cuba and Italy. He attended the stochastics working group in the III

CIBEM, Caracas, 1998.

Tim A Burgess, Department of Learning and Teaching, College of Education,Massey University, Private Bag 11-222, Palmerston North, New Zealand. email:t.a.burgess@massey.ac.nz

Tim is a senior lecturer at Massey University, in Mathematics Education. He teaches in both the preservice primary education programme as well as the secondary preservice programme. As he has just completed his masterate (for which his thesis was based on research with 11 and 12 year old children), he has a particular interest in statistics education.

Maria Carolina C. C. Carneiro, Faculdade de Educaçao, Universidad de Sao Paulo, Brazil. email:mcarolinaccc@sol.com.br

Maria Carolina C. C. Carneiro is lecturing Statistics at two universities. She is also preparing a doctoral dissertation at the Faculdade de Educaçao in the Universidade de Sao Paulo on the learnig of Statistics at primary school.

Lizet Sánchez, Instituto de Medicina Tropical "Pedro Kourí", Autopista Novia del Mediodía Km 6, PO. Box 601 Marianao 13, Ciudad de La Habana, Cuba. email:lsanchez@ipk.sld.cu

Lizet is preparing a project on the topic: Statistics as a social process in research, teaching and applications. He would appreciate any information and help.

José Loreto, Universidad Central de Venezuela, Ipostel Av. Nueva Granada, P.O. Box 40434, Caracas 1040-A, Venezuela. email:joseloreto@yahoo.com, loreto@camelot.rect.ucv.ve

José is a lecturer in statistics in the Faculty of Education, at the Universidad Central de Venezuela, and is also the head of this department. He is preparing a WEB Site on teaching basic statistics and is interested in exchanging information on related projects.

Faiza Tabassum, NA 404/32, 7th Road, Satellite Town, Rawalpindi, Pakistan. email:cashef@unforgettable.com

Faiza has been working as Lecturer for the last ten years in the department of Mathematics, Statistics & Computer Sciences at the Allama Iqbal Open University, Islamabad in Pakistan. She is also a member of IASE and is trying to start a Master or Doctoral Program in Education or Statistics to prepare a thesis on statistics education.

Note: Group members' names will be highligthed in capitals.

---

5. Brief News

5.1. New Project on Innovative Electronic Learning Environment

Tjaart IMBOS <tjaart.imbos@STAT.UNIMAAS.NL> reports on an innovative electronic learning environment for mathematics and statistics education developed in collaboration with Gilberte SCHUYTEN (Gilberte.Schuyten@rug.ac.be), Katy Goeminne (Katy.Goeminne@rug.ac.be) and Hannelore Dekeyser (Hannelore.Dekeyser@ouh.nl).

ILO, or "Innovative electronic learning environment for mathematics and statistics education", supports the innovation of statistics and mathematics education by means of the construction of an interactive, multimedia learning environment. This electronic learning environment (*ELO*) offers possibilities for differentiation according to student characteristics, for the stimulation of the

learning activity and for different modes of implementation. The *ELO* will be used in different Flemish institutes for Higher Education as a preparation for the entrance of higher education or as a remedial or supportive tool for learning mathematics and statistics.

ILO contains two subprojects. In the first subproject, which focuses the construction of some modules for the *ELO*, embedding didactical support devices is a central issue. This *ELO* will be implemented as an independent learning environment or as an additional source of information, complementing the traditional lectures and it will offer possibilities for hands on sessions. In the second subproject a series of Java-applets is constructed in order to illustrate different statistical concepts. These applets will be implemented as tools for demonstration during the traditional lectures or can be used in hands on sessions after the lectures. In addition to the construction of the modules of the *ELO* and the Java-applets, the project focuses the implementation, evaluation and dissemination of the products. *ILO* is a project of the Flemish Fund for the Stimulation of the Innovation of Higher Education and is a co-operation between the University of Gent, the Catholic University of Leuven, the Free University of Brussels, the School for Higher Education of Gent and the Open University of the Netherlands.

Further developments focus on the elaboration of the electronic learning environment of the *ILO*-project in order to support problem-based learning. By means of delivering learning contents through realistic cases, assignments or problems students are confronted with the practical value and usefulness of mathematics and statistics, are getting more involved in the learning contents. Problem-based learning is considered as a way to improve students' competencies and self-confidence in solving problems that are based on statistical and mathematical contents. The project *EPO* aims at the construction of a Virtual Centre for Expertise on Problem Based learning. This virtual centre is a web-site with information on problem-based learning, methods for evaluation and expertise on educational technology. The database also contains a set of cases with elaborated examples for teachers. A second aim of the project is to optimise the functionality of the *ELO* constructed in the *ILO*-project in order to support both problem-based learning and traditional thematic learning and to provide study-advise adapted to students' learning styles. Finally a lot of attention of the project is going to the exchange of knowledge and experience on problem-based education, the exchange of learning materials for problem-based learning and the evaluation of experimental forms of education. Similar as the *ILO*-project, the *EPO* project is founded by the Flemish government. The project is set up as a co-operation between the *ILO*-group and the Maastrich University.

5.2. A New CD-Rom to Help in the Teaching of Statistics

A CD- Rom on the teaching of statistics, in its second edition directed to high school and University students has been prepared by researchers in *CNAM* (Paris and Languedoc-Roussillon) and l'*AGRO*-Montpellier. Gilles Caraux and Gilbert Saporta chaired these teams.

This is an interactive course of basic statistics. Each concept is illustrated by examples and along the lesson some questions serve to assess understanding. Summaries and a variety of interactive exercises complement the course. More information is available from the web site: http://www.cnam.agropolis.fr/statnet/info/

5.3. Assessment of Statistical Knowledge

Kari MILLER (klmiller@unm.edu) in preparing a project entitled: "Some issues in the design of an assessment of statistical knowledge of students in an introductory class."

Currently advocated instructional goals in introductory statistics classes at the postsecondary level emphasise the utilisation of statistical methodology and the critical consumption of research

results. An understanding of the assessment of problem-solving goals such as these can be more adequately achieved within a theoretical framework which unites learner characteristics and the nature of the subject matter with assessment devices which are capable of measuring attainment of these goals.

This project evaluates the intersection of several major theories of knowledge representation (memory), learner impediments to developing accurate statistical concepts, some of the structural aspects of the domain of statistics, and assessment devices which purport to measure the structural aspects of a learner's domain knowledge. Special attention is devoted to the concept map as a measure of the structural aspects of knowledge. A concept map used in 1998 as a post-course measure of structural knowledge is critiqued in light of the theoretical framework developed in the paper. Recommendations are given for future research in the development of concept maps which can be utilised to measure attainment of problem-solving outcomes of an introductory statistics class.

---

6. Summaries of Publications by Members

GARFIELD, J., DELMAS, R., & Chance, B. (1999). The role of assessment in research on teaching and learning statistics. Paper presented at the *Annual Meetings of the American Educational Research Association*, Montreal, Quebec, April 18-23, 1999.

This paper examines the role of assessment in research studies focused on the teaching and learning of statistics at the undergraduate or graduate level. Some advantages and limitations for types of assessment methods typically used in statistics education research studies are summarised. An alternative framework is offered for conceptualising assessment and its role in studies of statistics education. This framework is based on the theory of conceptual change. An illustration will be offered: a study of the impact of the use of computer simulations on learning statistical inference. Examples of the types of assessment embedded in this ongoing research project will be shared

DELMAS, R., GARFIELD, J., & CHANCE, B. (1999). Exploring the role of computer simulations in developing understanding of sampling distributions. Paper presented at the *Annual Meetings of the American Educational Research Association,* Montreal, Quebec, April 18-23, 1999.

This paper examines the role of assessment in research studies focused on the teaching and learning of statistics at the undergraduate or graduate level. Some advantages and limitations for types of assessment methods typically used in statistics education research studies are summarised. An alternative framework is offered for conceptualising assessment and its role in studies of statistics education. This framework is based on the theory of conceptual change. An illustration will be offered: a study of the impact of the use of computer simulations on learning statistical inference. Examples of the types of assessment embedded in this ongoing research project will be shared.

HAWKINS, A. (1999). What is the International Statistical Institute? *Teaching Statistics,* 21(2), 34-35.

This is he second of a short series of articles in *Teaching Statistics* where the organisations that sponsor the journal are described.

LESSER, L. (1999). Exploring the birthday problem with spreadsheets. *Mathematics*

Teacher, May, 1999.

Multiple approaches to the famous Birthday Problem are explored and compared, addressing probability concepts, modelling issues, spreadsheets, recursion, problem solving, and simulation. In particular, an approximate approach based on opportunities is explored and found to be very accurate and useful in explaining the surprising result of how few people are needed for a birthday match to be likely. Connections are made to actual student performance and conceptions.

LESSER, L. (1999). The y's and why nots of line of best fit. *Teaching Statistics,* 21(2).

This article presents a sequence of explorations and responses to student questions about the rationale for the commonly used tool of line of best fit. A non calculus-based motivation is more feasible than may be assumed for each aspect of the least-squares criterion "minimise the sum of the squares of the vertical deviations between the fitted line and the observed data points.

LEVIN, J. R. (1998). What if there were no more bickering about statistical significance tests? *Research in the Schools*, 5(2), 43-53.

Questions and concerns are directed to those who advocate replacing statistical hypothesis testing with alternative data-analysis strategies. It is further suggested that: (1) commonly recommended hypothesis-testing alternatives are anything but perfect, especially when allowed to stand alone without an accompanying inferential filtering device; (2) various hypothesis-testing modifications can be implemented to make the hypothesis-testing process and its associated conclusions more credible; and (3) hypothesis testing, when implemented intelligently, adds importantly to the storytelling function of a published empirical research investigation.

LEVIN, J. R., & Robinson, D. H. (1999). Further reflections on hypothesis testing and editorial policy for primary research journals. *Educational Psychology Review*, 11, 143-155.

Questions have recently been raised about the value of statistical hypothesis testing, as well as the associated policy implications for publishing empirically based research in professional journals. In this Reflections note, we extend our (Robinson & Levin, 1997, *Educational Researcher*, Vol. 26, pp. 21-26) earlier thoughts on what could, should, and should not be done to existing editorial practices.

Keselman, H. J., Huberty, C. J., Lix, L. M., Olejnik, S., Cribbie, R. A., Donahue, B., Kowalchuk, R. K., Lowman, L. L., Petoskey, M. D., Keselman, J. C., & LEVIN, J. R. (1998). Statistical practices of educational researchers: An analysis of their ANOVA, MANOVA, and ANCOVA analyses. *Review of Educational Research*, *68*, 350-386.

Articles published in several prominent educational journals were examined to investigate the use of data analysis tools by researchers in four research paradigms: between-subjects univariate designs, between-subjects multivariate designs, repeated measures designs, and covariance designs. In addition to examining specific details pertaining to the research design (e.g., sample size, group size equality/inequality) and methods employed for data analysis, the authors also catalogued whether (a) validity assumptions were examined, (b) effect size indices were reported, (c) sample sizes were selected on the basis of power considerations, and (d) appropriate textbooks and/or articles were cited to communicate the nature of the analyses that were performed. The present analyses imply that researchers rarely verify that validity assumptions are satisfied and that, accordingly, they typically use analyses that are nonrobust to assumption violations. In addition, researchers rarely report effect size statistics, nor do they routinely perform power

analyses to determine sample size requirements. Recommendations are offered to rectify these shortcomings.

SHAUGHNESSY, J. M., WATSON, J., MORITZ, J., & READING, C. (1999). School mathematics students' acknowledgement of statistical variation. Paper presented at the NCTM Research Presession Symposium: *There's More to Life than Centers*. San Francisco.

Although research has been done on students' conceptions of centres (averages, means, medians), there has not been a corresponding line of research into students' conceptions of variability or spread. In this paper we describe several exploratory studies designed to investigate school students' conceptions of variability. A sampling task that was a variation of an item on the 1996 National Assessment of Educational Progress (NAEP) was given to 324 students in Grades 4 - 6, 9, and 12 from Oregon, Tasmania, and New South Wales. Three different versions of the task were presented in a Before, and in a Before and After setting. The Before and After students did the task both before and after carrying out a simulation of the task. Responses to the sampling task were categorised according to their centres (Low, Five, High) and spreads (Narrow, Reasonable, Wide). Results show a steady growth across grades on the centre criteria but no clear corresponding improvement on the spread criteria. There was considerable improvement on the task among the students who repeated it after the simulation. Students' growth on the centre criteria may be due to the emphasis that instruction places on centres in school mathematics. Similarly, the lack of clear growth on spreads and variability, and the inability of many students to integrate the two concepts (Centers and spreads) on this task, may be due to instructional neglect of variability concepts.

WATSON, J. M. (1999). Professional development for teachers of probability and statistics. Into an era of technology. *International Statistical Review,* 66(3), 271-290.

The focus of this paper is the professional development of teachers of probability and statistics at school level. Within a world where the statistics curriculum is changing at school level, the professional development needs of teachers of statistics are changing and the technology to meet these needs is changing as well. This paper reviews the work in the filed, describes the development of a multimedia package for professional development of statistics teachers and looks to the future.

---

7. Recent dissertations

BURGES, T. (1999). *Do games help the learning of probability?*. Master's dissertation. University of Massey.

The value of using games to assist students' learning of probability concepts was investigated, primarily using qualitative methods. Games, although generally useful in mathematics for helping children learn, may not automatically be as useful in helping students develop normative probability concepts, particularly because of the nature of randomness.

Sixteen students (Years 7 and 8) participated in the study. The students initially completed a written questionnaire which was designed to explore their understanding of probability. The students' misconceptions were categorised according to various types of probability reasoning. Two games were played by the students in groups of four, over two successive days; a game of chance on the first day, and a game of strategy and chance on the second. The game sessions, each lasting about 45 minutes, were audio-taped and video-taped. Group interviews were conducted during and following the playing of the games.

The study found differences between students in their levels of involvement in and discussion about the games, and differences between the two types of games in the degree of interaction within groups, all of which influenced the games's effectiveness in developing probability learning by the students. There was evidence of inconsistencies in some students' probability reasoning and understanding. When the empirical results from the games conflicted with their ideas, the students were not necessarily aware of such conflict so consequently did not adjust their thinking. For the use of such games to maximise the opportunities for the students' learning of probability, some implications of the study for classroom teachers are suggested. Consequently the role of and knowledge and understanding of the teacher is critical to ensure effective learning of probability concepts by students.

PFANNKUCH, M. (1999). *Characteristics of statistical thinking in empirical enquiry*. PhD thesis, The University of Auckland. Supervisor: Chris WILD.

There is an increasing emphasis in teaching, to develop students' capacity to think statistically. Thus, my thesis was undertaken to make explicit, and to document, the reasoning and thinking processes used by students and statisticians in applied statistics. It is an investigation into the nature of statistical thinking in the broad problem solving domain from problem formulation to conclusions. The research is based around four exploratory studies. In the first two studies statistics students were given tasks ranging from textbook-type questions to newspaper articles. The third and fourth studies involved interviewing professional statisticians and undergraduate statistics students about their approach to statistical problem solving in projects they had undertaken. Data were collected through recorded interviews. A qualitative research approach was used in each of the four exploratory studies and involved an ongoing analysis and interpretation of the data. Some of the qualitative data were analysed using software to aid the extraction of common themes. Other researcher and interviewee corroboration of the findings were used where possible.

From this research I have posited a four-dimensional statistical thinking framework for empirical enquiry. The dimensions are: the investigative cycle; the interrogative cycle; types of thinking; and dispositions. An inherently statistical way of thinking was identified as 'transnumeration' (a coined word). Other specifically statistical ways of thinking, such as taking variation into account, and the synthesising of context and subject knowledge, were found. These corroborated with other literature sources and therefore this thesis elaborates and extends this knowledge base with particular regard to the role of explanation or causation. Dispositions necessary for good statistical thinking are discussed in relation to statistics. An interrogative cycle has been created to explain how the identified generic thinking skills are specifically used in statistical thinking. Other types of thinking identified have been categorised as reasoning with models, strategic thinking and using techniques.

From all these elements a comprehensive grounded theory on the nature of statistical thinking in the broad problem solving domain has been developed from the data and literature. The implications arising from this theory for teaching are discussed, together with possible solutions based on the development of thinking tools.

Erica J. MORRIS (1999). *The design and evaluation of Link: a CAL system designed to address psychology students' misconceptions about correlation*. PhD Thesis. Institute of Educational Technology, The Open University, UK.

This thesis describes the design, development and evaluation of Link, a computer-assisted learning program for correlation, which is targeted at psychology students in higher education. Computer technology is being increasingly used on statistics courses, suggesting that computer-assisted

learning programs on statistical concepts will be increasingly used by students in higher education

To inform the design of Link, an empirical study was conducted to investigate students[1] difficulties with correlation. It was found that psychology students held misconceptions relating to negative correlation, the strength of correlation and that they infer causality. The design of Link was also informed by research-based principles of learning, research and developments in computer-assisted learning and a review of computer-assisted learning programs that cover correlation. A formative evaluation study involving eighteen psychology students found that having used the program, students[1] general understanding of correlation was significantly improved.

Unlike previously existing computer-assisted learning programs that were reviewed, Link makes use of data from two authentic studies in psychology. In addition, Link provides learner activities specifically designed to address students[1] misconceptions about correlation. A summative evaluation study of Link involving fifty psychology students was undertaken to assess the effect on students[1] understanding of correlation. The findings of this evaluation provided further qualitative data on students[1] misconceptions. Moreover, it was found that the use of Link significantly contributed to students[1] general understanding of correlation.

> Sánchez-Cobo, F.T. (1.999). *Significado de la correlación y regresión para los estudiantes universitarios* (Meaning of correlation and regression for the university students). Ph.D. Dissertation. University of Granada. Supervisors: Carmen BATANERO and Antonio ESTEPA.

In this research the contents introduced in the descriptive study of correlation and regression, both at High school and introductory University levels are analysed. A second aim was to characterise the personal meaning that university students give to these topics at the end of an introductory statistics course. An assessment questionnaire was given to a sample of 193 students at the University of Jaén. From their written responses to 20 multiple- choice items we compared the percentages of correct and incorrect answers related to different conceptual elements of the meaning of correlation and regression. We performed a quantitative study of the accuracy in estimating the correlation coefficient from different representations of the bivariate data set (tabular, graphical, verbal) from the students' solutions and arguments to a set of 30 open-ended tasks. We also analysed the effect of representation, sign and strength of correlation and students' previous theories on these estimations, as well as students' strategies to solve these tasks. Students' conceptual and procedural errors and solving strategies were also assessed from their solution to two additional open- ended problems.

As regards our first aim, the main contributions of our study is a sequence suggested for the teaching of the correlation and regression, the elaboration of a taxonomy to define the diverse concepts, the analysis of proofs, and the study of exercises and examples presented in the textbooks. All of this is useful to describe the elements of the meaning of correlation and regression. With regards the second objective, our results are used to characterise the personal meaning that university students give to correlation and regression. The assessment instrument, the implications for teaching, our set of references as well as our suggestions for further research can also be valuable for teaching and research on this topic.

---

8. Bibliography on Averages

Linda GATTUSO, Université de Québec á Montréal

Outsiders are frequently surprised that researchers are interested by such a 'simple' concept as the average. As we can see in this bibliography (which does not claim to be comprehensive) the

concept of average (and related concepts) together with its learning and teaching has been studied, but there is still a lot to look into. The readers interested in the subject should first seek the 'incontournable': Pollatsek et al. (1981), Mevarech (1983), Strauss & Bichler (1988), Mokros & Russell (1995).

Concept: The first consideration is the concept itself. What does it mean? Where does it come from? How is it used or understood? You will find a few answers in the following papers.

Angers, C. (1989). Moyenne arithmétique ou moyenne pondérée? [Arithmetic mean or weighted mean?]. *Bulletin AMQ*, May, 9-10.

Conway, F. (1977). Some uses of averages. *Mathematics in School*, 6 (4), 2-5.

Delahaye, J. P. (1992). L'espérance mathématique [Mathematical hope]. *Pour la science*, 76-81.

Diderot, D. (1778). *Encyclopédie ou dictionnaire raisonné des sciences, des arts et des métiers* [Encyclopedia or analytic dictionary of the sciences, arts, and trades] (Tome 22, pp. 492). Genève: Pellet.

Eisenbach, R. (1994). *What does the mean mean?* Photocopy distributed at ICOTS4.

GATTUSO, L. (1999). La moyenne: un concept inexploité, d'une richesse exceptionnelle [The mean: an unexplored concept of exceptional richness]. *Repères-IREM*,34, 79-93.

GIRARD J. C. (1998). A bas la moyenne! ou à propos des paramètres de tendance centrale et de dispersion d'une série statistique [Down with the mean! Or a discussion of measures of central tendency and dispersion for statistical data]. *Repères-IREM*, 33.

Grandsaignes d'Hauterive, R. (1948). *Dictionnaire des racines des langues européennes* [Dictionary of the origins of European languages] (p. 120). Paris: Librairie Larousse.

Hocquet, J. C. (1995). *La métrologie historique* [A history of measurement]. Paris: Presses universitaires de France.

Hodges, J. L., Krech, D., & Crutchfield, R. (1979). Le théorème central limite, multidétermination et normalité [The central limit theorem, multiple dependence and normality]. *Statlab*. Paris: Economica.

Kimberling, C. (1984). Mean, standard deviation, and stopping the stars. *Mathematics Teacher*, November, 633-636.

Korithoski, T., & Korithoski, P. (1993). Mean or meaningless? *Arithmetic Teacher*, December, 194-197.

Lavoie, P., & GATTUSO, L. (1998). An historical exploration of the concept of average. In *Proceedings of the Fifth International Conference on Teaching Statistics* (pp. 1051-1058). Singapore: International Statistical Institute.

Lubecke, A. M. (1991).Which mean do you mean? *Mathematics Teacher*, 84 (1), 24-28.

Mitchem, J. (1989). Paradoxes in averages. *Mathematics Teacher*, 82 (4), 250-253.

Moreau, R. (1972). Préface á la 19e edition du Dictionnaire des termes techniques et de médecine [Preface to the 19th edition of the Dictionary of technical and medical terms], *Dictionnaire des termes techniques et de médecine* (pp.v-viii). Paris: Maloine.

Pichard, J. F. (1993). Approche historique de la notion de valeur centrale d'une série statistique [Historical approach to the idea of the central value of statistical data]. *Statiquement vôtre*, 2, 8-10.

Planckett, R. L. (1970). The principle of the arithmetic mean, *Studies in the history of statistics and probability* (pp.121-126). London: Griffin.

Porter, T. M. (1986). *The rise of statistical thinking: 1820-1900*. Princeton: Princeton University Press.

Schwartzman, S. (1993). An unexpected expected value. *Mathematics Teacher*, 118-120.

Research: Next, it is interesting to look at research papers concerning misconceptions, errors or the effect of teaching and other experiments.

BATANERO, C., GODINO, D., VALLECILLOS, A., GREEN.D., HOLMES, P. (1994). Errors and dificulties in understanding elementary statistical concepts, *International Journal of Mathematics Education in Science and Technology* , 25 (4), 527-547.

BATANERO, C., GODINO, J. D., & Navas, F. J. (1997). Some misconceptions about averages in prospective primary school teachers. In *21st Conference of the International Group for the Psychology of Mathematics Education*, July 14-19, 1997 (v.1, p. 276). Lahti, Finland.

Beattie, K. (1995). Training in the law of large numbers and everyday inductive reasoning: a replication, with implications for statistics course design. *International Journal of Mathematics Education in Science and Technology,* 26 (6), 795-808.

Burrill, G., et al. (1992). *Data analysis and statistics across the curriculum* Reston, VA: National Council of Teachers of Mathematics.

Cai, J. (1995). Beyond the computational algorithm. Students' understanding of the arithmetic average concept. In L. Meira & D. Carraher (Eds.), *Proceedings of the 19th PME Conference* (vol. 3, pp. 144-151). Universidade Federal de Pernambuco

Cai, J., & Moyer, J. C. (1995). Middle school students' understanding of averages: A problem solving approach. In D. T. Owens, & M. K. Reed (Eds.), *Proceedings of the International Group for the Psychology of Mathematics Education. North American Chapter XVII* (v.1, pp. 359-364) Ohio State University.

Cai, J., Moyer, J. C., & Grochowski, N. J. (1997). Making the mean meaningful: Two instructional studies. Paper presented at the *Annual Meeting of the American Educational Research Association*. Chicago IL, March 24-28.

Caldwell, R. (1992). Teaching the effects of additive and/or multiplicative constants on the mean, moments about the mean, and correlation. Paper presented at the *Annual*

Meeting of the American Educational Research Association. San Francisco CA, April 20-24.

Callingham, R., A. (1994). Teachers' cognitive functioning in the context of questions using the arithmetic mean. In G. Bell, B. Wright, N. Leeson & J. Geake (Eds.), *Challenges in mathematics education: constraints on construction* (pp. 539-545). Proceedings of the Seventeenth Annual Conference of the Mathematics Education Research Group of Australasia. Lismore, Australia.

Carr, J.A. (1993). *Students' ideas on average and dispersion: a qualitative study involving year seven and eight students*. MEd. Thesis, University of Waikato, Hamilton, New Zealand.

Cudmore, D. (1996). The middle of what?: Students' images of mean, median and mode In L. Puig, & A. Gutierrez (Eds.), *Proceedings of the XX PME Conference on the Psychology of Mathematics Education* (vol. 1, p 166). University of Valencia.

Dreyfus, A. (1996). Are the notion of mean and related concepts too difficult for 6th and 7th grade biology students? *European Journal of Teacher Education*, 19 (2), 137-152.

Flores, A. (1998). Mean machines. *Mathematics Teacher,* 91 (3), 266-268.

Frierson, D., Berenson, S., BRIGHT, G. W., & FRIEL, S. N. (1996). Elementary teachers' understanding of the arithmetic mean. Paper presented at the *Annual Conference of the Research Council for Diagnostic and Prescriptive Mathematics*, Melbourne, FL. (Brightg@Steffi.Uncg.Edu).

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

GARFIELD, J., & AHLGREN, A. (1988a). Difficulties in learning basic concepts in probability and statistics: implications for research. *Journal for Research in Manthematics Education*. 19, 4-63.

GARFIELD, J. & AHLGREN, A. (1988b). Difficulties in learning probability and statistics. In R. Davidson, & J. Swift (Eds.), *Proceedings of the Second International Conference on Teaching Statistics* (pp. 270-274). Victoria BC: University of Victoria.

GATTUSO, L. (1997). La moyenne, un concept élémentaire? [Is the mean an elementary concept?]. *Orthoégraphe plus*.

GATTUSO, L., & Mary, C. (1997). La moyenne, un concept évident? [Is the mean and obvious concept?] *Bulletin de l'AMEP*, XXXVII (3), October, 10-19.

GATTUSO, L., & Mary, C. (1996). Development of concepts of the arithmetic average from high school to university. In L. Puig, & A. Gutiérrez (Eds.), *Proceedings of the 20th International Conference for the Psychology of Mathematics Education* (vol. 2, pp. 401-408). University of Valencia

GATTUSO, L., & Mary, C. (1998). Development of the concept of weighted average among high-school children. In *Proceedings of the Fifth International Conference on Teaching Statistics* (pp. 685-692). Singapore: International Statistical Institute.

George, E. A. (1995). Procedural and conceptual understanding of the arithmetic mean: A comparison of visual and numerical approaches. In D. T. Owens, & M. K. Reed (Eds.), *Proceedings of the International Group for the Psychology of Mathematics Education. North American Chapter XVII* (v.1, pp. 204-209). Ohio State University.

Leon, M. R., & Zawojewski, J. S. (1993). Conceptual understanding of the arithmetic mean. Paper presented at the *Annual Meeting of the American Educational Research Association,* Atlanta GA, April 12-16.

Mevarech, Z. R. (1983). A deep structure model of students' statistical misconceptions. *Educational Studies in Mathematics*, 14, 415-429.

Mokros, J., & Tinker, R. (1987). The impact of microcomputer-based science labs on children's abilities to interpret graphs. *Journal for Research in Science Teaching*, 24, 369-383.

Mokros, J., & Russell, S. (1991). Toward an understanding of mean as balance point. In R.G. Underhill (Ed.), *Proceedings of the Thirteenth Annual Meeting of the North American Chapter of the International Group for the Psychology of Mathematics Education, PME-XI* (pp. 189-195). Blacksburg: Virginia Polytechnic Institute and State University.

Mokros, J., & Russell, S. (1995). Children's concepts of average and representativeness. *Journal for Research in Mathematics Education*, 26 (1) 20-39.

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

Roth, Leon, M., & Zawojewski, J. (1990). Use of arithmetic mean: An investigation of four properties issues and preliminary results. In D. Vere-Jones (Ed.), *Proceedings of the Third International Conference on Teaching Statistics* (pp. 302-306). Dunedin, New Zealand.

Russell, S., & Mokros, J. (1990). What's typical? Children's and teachers' ideas about average. In David Vere-Jones (Ed.), *Proceedings of the Third International Conference on Teaching Statistics* (pp. 307-313). Dunedin, New Zealand.

Russell, S., & Mokros, J. (1996). Research into practice: What do children understand about average? *Teaching Children Mathematics*, 2 (6), 360-365.

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

Silver, E. A. (1982).The average of 60 and 100 is not always 80: The harmonic mean in first-year algebra. *School Science and Mathematics*, 82 (8), 682-686.

Strauss, S., & Bichler, E. (1988). The development of children's concepts of the arithmetic average. *Journal for Research in Mathematics Education* 19 (1), 64-80.

Thibodeau H., P., Weel, A., & Pollatsek, A. (1984). Usefulness of a balance model in understanding the mean. *Journal of Educational Psychology*, 76 (5), 792-801.

Watson, J. M., Collis, K. F., & Moritz, J. B. (1996). *Authentic assessment of the concept of average: A developmental approach*. Report prepared for the National Centre for Research in Mathematical Sciences Education Models of Authentic Assessment Working Group (University of Wisconsin) (51 pp.). Hobart: Department of Education, University of Tasmania.

Well, A. D., Pollatsek, A., & Boyce, S. (1990). Understanding the effects of sample size on the variability of the mean. *Organizational Behavior and Human Decision Processes*, 47, 289-311.

White, A. L., & Berlin, D. (1989). SSMILES. Fulcrum and mean: Concepts of balance. High School/College. *School Science and Mathematics*, 89 (4), 335-342.

Teaching Activities: Although there is still a lot to be said concerning the teaching of the average, the following papers present teaching experiences or suggest activities for the clasroom

Aureli, E. (1994). La statistique et les enfants: Comment les aider á saisir le concept de moyenne, ses implications et ses applications [Statistics and children: how to help them to grasp the idea of the mean together with its implications and applications]. Paper presented at *ICOTS 4* Marrakech.

Ball, J. (1969). Finding averages with bar graphs. *Arithmetic Teacher*, 16 (6), 487-489.

Ballman, K. (1977). Greater emphasis on variation in an introductory statistics course. *Journal Of Statistics Education* 5(2).

Barbella, P. (1987). Realistic examples in elementary statistics. *Mathematics Teacher*, December, 740-743.

Barr, G. (1980) Some student's ideas on the median and mode. *Teaching Statistics*, 2. 38-41.

Duperret, J. C. (1992). La médiane au collège [The median at college]. *Mathématiques chez les 11-16 ans en France*. In ICME-7 (pp. 72-76). Québec.

Glencross, M. (1988). A practical approach to the central limit theorem. In R. Davidson, & J. Swift (Eds.), *Proceedings of the Second International Conference on Teaching Statistics* (pp. 287-291). Victoria BC, University of Victoria.

Kundert, K. (1990). Student generated data in elementary statistics. *Mathematics Teacher*, April, 332-325.

Lappan, G., & Zawojewski, J. (1988). Teaching statistics: Mean, median, and mode. *Arithmetic Teacher*, 88, March, 25-26.

Paull, S. (1991). Not just an average unit. *Arithmetic Teacher*, 38 (4), 54-58.

Penafiel, A.F., & White, A. L. (1989). SSMILES. Exploration of the mean as a balance point. *School Science and Mathematics*, 89 (3), 251-258.

Sommers, J. (1992). Statistics in the classroom: Written projects portraying real-world situations. *Mathematics Teacher*, 85 (4), 310-313.

Tessier, H. (1995). *La moyenne d'une distribution* [The mean of a distribution]. Commission scolaire, Baldwin-Cartier photocopy.

Vonder E. C., & Engebretsen (1996). Visual representation of mean and standard deviation, *Mathematics Teacher*, 89 (8), 688-692.

More references

Aillo-Hatchman, J. & Duren, P. E. (1991). It's not all garbage! *School Science and Mathematics*, 91(6), 272-275.

Book, S. A., & Sher, L. (1979). How close are the mean and the median? *Two-Year College Mathematics Journal*,10(3), 202-204.

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

Carr, J. (1993). Student ideas on measures of central tendency and dispersion. Paper presented at the *NZARE Conference*, University of Waikato, New Zealand, December, 1993.

Cassell, D. (1989). What do we mean by the mean? *Teaching Statistics*, 11 (2), 38-39.

Ernest, P. (1986). Statistics and the media. *Mathematics in School*, 15 (3), 14-15.

FALK, R (1981). Another look at the mean, median, and standard deviation. *Two-Year College Mathematics Journal*, 12 (3), 207-208.

FALK, R., & Bar-Hillel, M. (1980). Magic possibilities of the weighted average. *Mathematics Magazine*, 53 (2), 106-107.

FALK, R., & KONOLD, C. (1994). Random means hard to digest. *Focus on Learning Problems in Mathematics*, 16 (1), 2-12.

Flores, A. (1995). Connections in proportional reasoning: Levers, arithmetic means, mixtures, batting averages and speeds. *School Science and Mathematics*, 95 (8), 423-430.

FRIEL, S. N. (1998). Teaching statistics: What's average? In L. J. Morrow (Ed.), *The teaching and learning of algorithms in school mathematics* (pp. 208-217). Reston VA: National Council of Teachers of Mathematics.

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

GAL, I., Rothchild, K. & Wagner, D. A. (1990). Statistical concepts and statistical reasoning in school children: Convergence or divergence. Paper presented at the *American Educational Research Association Conference,* April, 1990, Boston MA.

Goldman, P. (1990). Teaching arithmetic averaging: An activity approach. *Arithmetic Teacher*, 37(7), 38-43.

Goodchild, S. (1988). School pupils' understanding of average. *Teaching Statistics*, 10

(3), 77-81.

Hardiman, P., Well, A. & Pollatsek, A. (1984). Usefulness of a balance model in understanding the mean. *Journal of Educational Psychology*, 76 (5), 792-801.

Joram, E. (1990). People's understanding of the weighted mean: Misconceptions vs inert knowledge. Paper presented at the *Annual Meeting of the American Educational Research Association*, Boston, MA.

Kozelka, R. M. (1979). Grade point averages and the central limit. *American Mathematical Monthly*, 86 (9), 773-777.

Litwiller, B. (1992). Student math notes: Mean means, meaner means, meanest means. *NCTM Student Maths Notes*, May 1992, 1-4.

Lovie, P. & Lovie, A. D. (1976). Teaching intuitive statistics. *International Journal of Mathematics Education, Science and Technology*, 7 (1), 29-30.

Maor, E. (1977). A mathematician's repertoire of means. *Mathematics Teacher*, 70, January, 20-25.

Meyer, J. (1995). Simple paradoxes in descriptive statistics. *Teaching Mathematics and its Applications*, 14 (2), 51-60.

Meyer, R. A. et al. (1995). Expanding students' conceptions of the arithmetic mean. *School Science and Mathematics*, 95 (3), 114-117.

Mitchen, J. (1989). Paradoxes in averages. *Mathematics Teacher*, 82, 250-253.

Mogull, R. G. (1990). Popular measures of central tendency. *Mathematics Teacher*, 83, 744-745.

Pollatsek, A., Konold, C., Well, A. D., & Lima, S. D. (1984). Beliefs underlying random sampling. *Memory and Cognition*, 12 (4), 395-401.

Rhiel, G. S. & Chaffin, W. W. An investigation of the large-sample/small-sample approach to the one-sample test for a mean (sigma unknown). *Journal of Statistics Education*, 4 (3).

Schlottmann, A., & Anderson, N. H. (1994). Children's judgments of expected value. *Developmental Psychology*, 30 (1), 56-66.

Steward, D. (1994). In mean mode. *Mathematics in Schools*, September, 34-39.

Zawojewski, J. S. (1988). Teaching statistics: mean, median, and mode. *Arithmetic Teacher*, March, 25-25.

The concept of average is a very rich concept and is fundamental in the understanding of statistics. This bibliography reveals the interest in this concept. Since it is one of Linda's research interest, she would be happy to add on this list or to receive comments or suggestions at <gattuso.linda@uqam.ca>.

---

9. Other publications of interest

Peterson, I. (1997). *The jungles of randomness*. London: Peguin.

The author explores the ambiguities and uncertainties of randomness and the interplay of order and disorder.

Rescher, N. (1995). *Luck. The brilliant randomness of everyday life*. New York: Farrar Strauss Giroux.

This book offers a realistic view of the nature and operation of luck to help us come to sensible terms with life in a chaotic world. Differentiating luck from fate and fortune, Rescher weaves a colour full tapestry of historical examples from antiquity to present. Luck cannot be manipulated or controlled, Rescher argues, but it can be managed to some extent.

Royal, R. (1997). *Statistical evidence. A likelihood paradigm*. London: Chapman & Hall.

This monograph addresses the general problem of interpreting statistical data as evidence and focuses on the Law of Likelihood, which is fundamental to the solution. Statistics has long neglected this principle, and has, for that reason produced a seriously defective methodology. This book redresses the balance, and explain why science has clung to that methodology despite its well known defect. Statistical evidence examines the strengths and weaknesses of the approach of Neyman and Pearson, and that by Fisher, and then proposes an alternative. This alternative paradigm provides, in the Law of Likelihood, the explicit concept of evidence that is missing from the others. At the same time it retains the elements of objective measurement and control of the frequency of misleading results, features which made the old paradigms an important part of science. The likelihood paradigm leads to statistical methods that have a compelling rationale and elegant simplicity, and no longer forces the reader to choose between frequentist and Bayesian statistics.

---

10. Complementary short references

BRIGTH, G.W., FRIEL, S.N. (1996). Connecting stem plots to histograms. In E. Jakubowski, D. Watkins, & H. Biske (Eds.), *Proceedings of the eighteenth annual meeting, North American Chapter of the International Group for the Psychology of Mathematics Education* (v. 1, pp. 235-240). Columbus: ERC Clearinghouse for Science, Mathematics and Environmental Education.

Carpenter, P. A., & Shah, P. (1998). A model of the perceptual and conceptual processes in graphs conprehension. *Journal of Experimental Psychology: Applied,* 2, 75-100.

FRIEL, S. N. (1998). Comparing data sets. How do students interpret information displayed using box plots? In S. Berenson, K. Dawkins, M. Blanton, W. Coluombe, J. Kolb, K. Norwood, & L. Stiff (Eds.), *Proceedings of the twentieth annual meeting, North American Chapter of the International Group for the Psychology of Mathematics Education* (v. 1, pp. 365-370). Columbus: ERC Clearinghouse for Science, Mathematics and Environmental Education.

Gani, J. (1999). Reflections on Pat Moran and the Australian statistical scene. *Teaching Statistics*, 21(2), 39-41.

Hald, A. (1998). *A history of mathematical statistics from 1750 to 1930*. New York: J.

Wiley.

Hanley, J. A., & Lippman, A. (1999). Where do you stand? Notions of the statistical "centre". *Teaching Statistics*, 21(2), 49-51.

Klein, J. L. (1997). *Statistical visions in time: A history of time series analysis*. Cambridge University Press.

Lesser, L. (1999). The 'Ys' and 'Why nots' of line of best fit. *Teaching Statistics*, 21(2),54-55.

11. Internet Resources of Interest

11.1. Tools for Teaching and Assessing Statistical Inference

Joan GARFIELD, Robert DELMAS, and Beth CHANCE are working on the "Tools for Teaching and Assessing Statistical Inference" project, funded by the National Science Foundation, to develop and disseminate materials that help students learn core concepts underlying statistical inference. They have created instructional modules that use simulation software to help students develop abstract concepts such as sampling distribution, confidence interval, p-values, and power. Based on their previous research, they have based the modules on a model of conceptual change where students first make predictions and then test them using the simulation software. These modules also include assessment instruments to assess prerequisite conceptual knowledge and instruments to assess understanding of the statistical concepts underlying statistical inference.

Their web site (http://www.gen.umn.edu/faculty_staff/delmas/stat_tools) contains materials for four instructional units (sampling distributions, confidence intervals, p-values, and power) as well as a variety of papers describing our development and evaluation of these materials. They invite you to browse our site, review our materials, and send them your feedback. More information is available from Joan GARFIELD: jbg@tc.umn.edu.

11.2. Information on Forthcoming Conferences in Education in South America

SINIEVENTOS is a newsletter written in Spanish with information on Forthcoming conferences all around the world. It can be consulted at the following web sites: Red Enlaces: (http://www.enlaces.cl); Universidad de Artes, Ciencias y Comunicacion: (http://www.uniacc.cl); and Consejo Superior de Educacion: (http://www. cse.cl).

12. Information on Past Conferences

12. 1. The Annual Conference of the Mathematics Education Research Group of Australasia (MERGA).

Report by John TRURAN.

MERGA was held at Adelaide, South Australia, 3- 7 July, 1999. The following papers on stochastics were presented and published in J. TRURAN, & K. M. TRURAN (Eds.) (1999). *Making the Difference. Proceedings of the Twenty-second Annual Conference of The Mathematics Education Research Group of Australasia, Incorporated*. Turramurra, New South Wales: MERGA Publications Officer. Copies of the Proceedings may be ordered from MERGA Publications Officer, 23/219 Kissing Point Road, Turramurra, New South Wales 2074. (mergapub@tpgi.com.au). The price (which includes postage) is AUD60 within Australia and New Zealand and AUD85 for the rest of the world.

Tim BURGESS. "Do games help the learning of probability?" (pp. 120- 127). (t.a.burgess@massey.ac.nz). This paper reports on a research project which investigated the value of using games to assist Year 7 and 8 students' learning of probability concepts. Games, although generally useful in mathematics for helping children learn, may not automatically be as useful in helping students develop normative probability concepts. The study found that the type of game impacted on the value of using games for learning probability, and that there are implications for the teacher's role when using games for learning.

Helen L. Chick. "Jumping to conclusions: Data interpretation by young adults" (pp. 151-158). (h.chick@edfac.unimelb.edu.au). The increased emphasis on the Chance and Data strand of the mathematics curriculum means students should be approaching adulthood better prepared to interpret data and recognise relationships between variables and between a sample and its corresponding population. This study examines the statistical appropriateness of conclusions drawn by young adults from data in a small sample. While many of the analyses took into account the data's limitations, there were still some erroneous assumptions and omissions.

Sharon Gunn. "Emerging themes in statistics education" (pp. 246-252). (sgunn@stats.waikato.ac.nz). This paper reports research in progress. It brings together some issues and themes emerging from the literature review (to date), preliminary interviews, personal reflections and earlier research. These will be extended and refined in further research and will be included in my thesis which focuses on the search for possible (shifting) paradigms within which statistics education (research and practice) is framed.

Jonathan B. MORITZ & Jane M. WATSON. "The conjunction fallacy and longitudinal development of chance expression" (pp. 380-387). (Jonathan.Moritz@utas.edu.au); (Jane.Watson@utas.edu.au).Two survey items asking for estimates of probability or frequency of everyday events (A), (B), and their conjunction (AandB), were completed by 2719 school students in grades 5 to 11. Cross-sectional and longitudinal analyses revealed chance expression improved with grade, but no change in incidence of conjunction errors. Gender differences favouring males occurred for some grades. Comparisons with responses to other probability items indicated incidence of conjunction errors is independent of development of basic chance measurement.

Lynne Outhred and Pamela F. SHAW. "Visual representations in first year statistics" (pp. 411-417). (Lynne.outhred@mq.edu.au); (Pamela.shaw@mq.edu.au).This paper summarises the findings of a study into the extent to which students in introductory statistics courses use diagrams when solving problems. The results of the study showed that many students did not use diagrams but those who used diagrams were more successful. Use of diagrams and university entrance score appeared to be better predictors of success than the level of mathematics studied at secondary school.

Jane M. WATSON & Jonathan B. MORITZ. "Longitudinal understanding of conditional probability by school students". (Jane.Watson@utas.edu.au); (Jonathan.Moritz@utas.edu.au) (pp. 522-529). Two survey items asking for estimates of probability or frequency of conditional events, (A|B) and (B|A), were completed by 2719 school students in grades 5 to 11. Cross-sectional and longitudinal analyses revealed improvement with grade in expressing probability numerically and in distinguishing conditional events. Conditional events were better distinguished for the frequency item than the probability item. Comparisons with responses to other probability items indicated understanding of conditional probability was related to development of basic chance measurement.

Anne M. WILLIAMS. "Novice student's conceptual knowledge of statistical hypothesis testing" (pp. 554-560). (am.williams@qut.edu.au). Examination of the statistical literature shows that

consensus on definition, terminology, and interpretation of some hypothesis testing concepts is elusive. This makes hypothesis testing a difficult topic to teach and learn. This paper reports on the results of a study of novice students' conceptual knowledge of four hypothesis testing concepts through talking aloud and interview methods. While some students seemed to have a reasonable understanding of some concepts, many students seemed to have more limited understanding. The study explores students' faulty conceptual knowledge.

12.2. SRTL. The First International Research Forum on Statistical Reasoning Thinking and Literacy. Report by Dani BEN-ZVI.

The Research Forum was held in Kibbutz Be'eri Israel, July 18-23, 1999 located in the beautiful northwest Negev hills, near the Gaza Strip, a one hour drive from Tel-Aviv, in Israel. This gathering took place under the umbrellas of the International Study Group for Research on Learning Probability and Statistics and the IASE. It was sponsored by the University of Minnesota, the Maurice and Gabriela Goldschleger Conference Foundation at the Weizmann Institute of Science, and Kibbutz Be'eri. The Forum was co-chaired by Joan GARFIELD (University of Minnesota, USA) and Dani BEN-ZVI (Weizmann Institute of Science, Israel), who are currently Vice-Presidents of the IASE.

The SRTL Forum offered an opportunity for a small, interdisciplinary group of researchers from six different countries (Australia, Belgium, Northern Ireland, Israel, UK, and US) to meet for five days, to share their work, discuss important issues, and initiate collaborative projects. Sessions were held in an informal style (110 minutes for each presentation), with a high level of interaction - given the group size. The sessions' themes and presenters were:

1. Variation in Sampling, Chris READING (Australia)
2. Understanding the Role of Variation in Correlation and Regression, James Nicholson (Northern Ireland)
3. Developing Statistical Reasoning about Sampling Distributions, Joan GARFIELD, Beth CHANCE, & Bob DELMAS (USA)
4. Statistical Reasoning in Visualisation: Constructing Meanings for Trend in Time Plots with Spreadsheets, Dani BEN-ZVI (Israel)
5. The Longitudinal Development of Reasoning to Make Inferences from Data Presented in Graphical Form, Jane WATSON (Australia)
6. Students' Use of Diagrams in Statistics, Pamela SHAW (Australia)
7. Averages (In Comparing Two Groups), Cliff KONOLD (USA)
8. Conceptualising Statistical Literacy: An Assessment Perspective, Iddo GAL (Israel).

We also had a group of discussants, who discussed and reflected on the presentations.

The discussants were: Janet Ainley (UK), Maya Bar-Hillel (Israel), Herman CALLAERT (Belgium), Brian GREER (Northern Ireland), Brian PHILLIPS (Australia), and Laurie SNELL (USA). We experimented in using videos of classroom work, or students' interviews, as a way to present, discuss and argue parts of the research work, we are immersed in. We have learnt that videos have much to offer, and that there is much to learn about the use of videos, as a research tool and a way to share our work.

The unique Kibbutz setting offered modern and excellent facilities, warm hospitality, and opportunities to tour the surrounding area. During the week we managed to take time out from our discussions to visit the Weizmann Institute of Science, where some of our colleagues gave a presentation to the mathematics and science education department. We also paid a tribute to Efraim FISHBEIN's memory, by taking part in a commemoration ceremony, which took place in

Tel-Aviv University. Joan GARFIELD, representing IASE, emphasised in her talk Fischbein's direct contribution to those of us working in the field of stochastic teaching and learning.

Our forum was very successful and is planned to lead to an edited book on Statistical Reasoning, Thinking and Literacy. The book will summarise the work presented, discussions conducted on theoretical, methodological, pedagogical, assessment, literacy and communication emerging issues. This was only the beginning of a very exciting and promising line of research. There is much work to be done. We hope to offer new or expanded networks, an e-mail discussion list, and a second Research Forum (SRTL-2) in the year 2001. If you would like to learn more about our research forum, or offer your contribution, please visit the SRTL web site (**file:///D:\newsletter\www.beeri.org.il\srtl**) or contact Joan GARFIELD (jbg@maroon.tc.umn.edu) or Dani BEN-ZVI (dani.ben-zvi@weizmann.ac.il).

12.3. 23rd conference of the International Group for the Psychology of Mathematics Education, The Technion - Israel Institute of Technology, 25-30 July 1999. Report by John TRURAN and Dani BEN-ZVI.

The annual Conference of 1999 was held in Haifa, Israel, from July 25 to July 30. There were the following Stochastics Presentations at PME, published in the Proceedings: Zaslavsky, Orit (Ed.) (1999). *Proceedings of the 23rd Conference of the International Group for the Psychology of Mathematics Education*. Haifa: Israel Technion & Israel Institute of Technology.

Research Reports

> Amir, G., Linchevski, L. & Shefet, M. The probabilistic thinking of 11-12 year old children (v.2, pp. 25-32).

This research explored the probabilistic thinking of 11-12 year old children in Israel. A questionnaire was developed, including scales that explore children's estimation of probabilities. 294 children completed the questionnaire, and 32 of them were also interviewed. Some of the main findings include: 'representative' sequences; most of the children did not discriminate between single sequences and classes of sequences; several new examples of children's use of the 'representativeness' and 'availability' heuristics were identified.

> Ayres, P. & WAY, J. (v.2, pp. 41-48). Decision-making strategies in probability experiments: The influence of prediction confirmation.

Two groups of grade six students observed a video-recording of coloured balls being drawn from a box (sample space unknown). After every fifth selection, students were required to predict the colour of the next ball drawn. One group observed a sequence where the most frequently occurring colour (white) was drawn 80% of the time following prediction, whereas for the second group, a white only appeared 20% following prediction. Even though the accumulated experimental probabilities prior to prediction for both sequences had been manipulated to be identical, the former group chose white more consistently than the latter group. Consequently, it was argued that children may be influenced in their probability judgements by confirmation or refutation of their 'prediction'.

> BEN-ZVI, D. (v.2, pp. 97-104). Constructing an understanding of data graphs

I describe episodes of two 13-year-old students working on Exploratory Data Analysis (statistics) developed within an innovative curriculum. I analyse the microevolution of their incipient understandings of some features of graphs as data representations. The description includes the role of the instructional materials, the students' discussions and collaborative attempts to solve the

tasks, and the teacher's intervention. Although her intervention seemed to be a miscommunication, it appears to have helped the students to make sense of their tasks.

ESTEPA, A., Sánchez-Cobo, F. T. & BATANERO, C. (v.2, pp. 313-320). Students' understanding of regression lines.

In this paper we present and discuss undergraduates' difficulties in finding the mean of a variable from the following data: mean of a related variable, slope and intercept of the regression line. Difficulties of the students in interpreting regression lines are described and implications for the teaching of regression are finally suggested.

OJEDA S., A. M. (v.4, pp. 1-8). The research of ideas of probability in the elementary level of education.

Ideas of probability have been investigated in Mexican elementary education. Two examples are given to illustrate the way in which epistemological aspects are considered in this research. Teaching experiments with 6- and 7-year old children suggest that pupils' interpretations of the tasks they were asked about may result in answers which do not inform on their idea of chance, since they tend not to focus on it. Additionally, by using questionnaires and clinical interviews with 10-15 year old children, it was found that correct performance on arithmetic does not assure that they can cope with questions about probability for which a quantification is required.

READING, C. (v.4, pp. 97-104).Understanding data tabulation and representation

Statistics has received increased recognition in mathematics school curriculum in Australia partially due to the strand status assigned to statistics (within Chance and Data) in A National Statement on Mathematics for Australian Schools. Consequently, research has focused on considering what 'statistical thinking' really means. To assist teachers to plan and assess the teaching of statistical concepts more needs to be known about students' statistical understanding. This paper takes up the theme by considering students' responses to two open-ended tasks, one of which presents the data in table form and the graphically. Both tasks require students to describe what they understand by the data representation. A developmental sequence of eight levels was identified and the responses to the two different data presentations were analysed. The SOLO Taxonomy was used as the theoretical framework to assist this process.

SHAW, P. F. & Outhred, L. (v.4, pp. 185-192). Students' use of diagrams in statistics.

This paper summarises the preliminary findings of a study into why students in an introductory statistics course do or do not use diagrams in questions which could be done with or without the use of a diagram. It was found that students were reluctant to use diagrams but those who used diagrams were more successful. Very little relation was found between the use of diagrams and previous maths studied.

TRURAN, J. M. & TRURAN, K. M. (v.4, pp. 281-288). Using a handbook model to interpret findings about children's comparisons of random generators.

The 'Handbook Model' developed by the first author is used here to provide an integrated summary of research into children's comparison of random generators which is accessible to teachers but highlights the known complexities of individuals' responses. Linking psychology with pedagogy highlights the meaning of earlier, only partially successful attempts to codify responses. Children's construction of probabilistic meaning in such situations must also take account of their inconsistent heuristics and approaches, the need for a generalisable non-numeric probability estimator, and the need to verify judgements in way which allow for the uncertainties involved in

any stochastic situation.

> TRURAN, K. M. & TRURAN, J. M. (v.4, pp. 289-296). Are dice independent? Some responses from children and adults.

This paper examines some understandings of the concept of independence of dice by comparing the results of an Italian study with that of four Australian studies. Roughly comparable groups produced quite different results, and similar reasons based on control were used to justify quite different responses. Some implications of these findings are discussed, especially with respect to the place of intuition in probabilistic thought and the lack of understanding of probability held by some pre-service teachers.

Short Oral Communications

> Kot, L. Kiro, S. & Arcavi, A. Mistaken conjectures as a trigger to develop basic probabilistic reasoning.

This presented an analysis of the ways in which students analysed the fairness of games similar to the 'fingers' game where each player shows a number of fingers between 0 and 5 and one player wins if the total is even and the other wins if the total is odd. Some had had prior instruction in probability and some had not. It was shown how students slowly changed their initial incorrect conjectures about the games by using table representations to make sense of the problem.

Poster Presentations

> Lane, D. M. The Rice virtual lab in statistics: A web resource for teaching statistics

This presentation described an electronic set of simulations/demonstrations, textbook, case studies, and data analysis program. The material is available at <http://www.ruf.rice.edu/~lane/rvls.html>.

PME Discussion Group for Stochastics Teaching and Learning

A PME discussion group is a group that wishes to discuss and share perspectives on a specific topic/domain. Each Discussion Group is allotted two 90-minute sessions in the PME conference. There is no expectation that a Discussion Group produce any published outcome. The PME International Committee approved our proposal to continue the meetings of a Discussion Group for Stochastics Teaching and Learning in PME24. In PME23, we have had two excellent meetings of this group. About 50 people participated actively in the discussions. Some of the issues discussed were:

1. Discussions on the relations (and the potential mutual contributions) between mathematics education and statistics education.

2. Continuation of the reviews of statistical research literature project. These are critical reviews of what are seen as important writings in stochastics education research. They include a short introduction and a bibliographic list. Few topics have already been covered, e.g., association, historical aspects of stochastic education, bayesian statistics. These reviews are edited by Carmen BATANERO (batanero@goliat.ugr.es, http://www.ugr.es/local/batanero/) and John TRURAN (jtruran@arts.adelaide.edu.au) and are published in this newsletter. Suggestions for new topics and commitments for reviewers are welcome!

3. We had proposed an overarching theme for the next Discussion Group (PME24, Japan, 2000), which was approved by the PME International Committee. The proposed theme for the next

meeting is: "*The relationship between stochastical and mathematical thinking, learning, and teaching*", which we hope will extend through further meetings. It is our intention to approach this theme from multiple perspectives, including:

- Philosophical, in terms of the perceived boundaries of the disciplines.
- Historical, in terms of the developments of the disciplines.
- Educational, in terms of the positioning and implementation of the teaching and learning of stochastics within school and tertiary curricula, including such fundamental issues as teacher development, assessment, and technology.
- Psychological, in terms of the specific cognitive and sociocultural processes involved in the teaching and learning of stochastics.
- Research, in terms of cross-fertilisation of theoretical frameworks and methodologies.
- We call for short contributions, which will be followed by discussions among members of the group.

4. We have experienced a leadership change: Carmen BATANERO resigned because of increased IASE involvement. Dani BEN-ZVI and Brian GREER joined Kath and John TRURAN in leading the group. It is our pleasure to thank Carmen Batanero for investing much energy, vision and time in the PME Stochastics Group for the past few years.

5. A mechanism already exists for electronic communication between potential participants through the *PME Stochastics Teaching and Learning Newsletter*, which has been circulating for four years. If you want to receive the newsletter via e-mail, please contact Dani BEN-ZVI (dani.ben-zvi@weizmann.ac.il). We hope to see you in PME24 (Hiroshima, Japan, July 23-27, 1999)!

PME Stochastics Discussion Group Co-ordinators: Dani BEN-ZVI (Israel) dani.ben-zvi@weizmann.ac.il, Brian GREER (Ireland) b.greer@qub.ac.uk, Kath TRURAN (Australia) kath.truran@unisa.edu.au, John TRURAN (Australia) jtruran@arts.adelaide.edu.au

PME Website: http://members.tripod.com/~IGPME/

PME23 Website: http://members.tripod.com/~IGPME/pme23/index.html

PME24, 23 - 27 July, 2000: The conference of 2000 will be held in Hiroshima, Japan. The First Announcement will be mailed in September to PME members of 1998 and later. For more information contact the conference secretary: Masataka Koyama, mkoyama@ipc.hiroshima-u.ac.jp,

http://www.ipc.hiroshima-u.ac.jp/~pme24/

12.4. IASE Invited Paper Meetings at the 52 Session of the International Statistical Institute.

Invited paper meeting n.58: *Statistical education and significance test controversy.* Organiser/Chair: Carmen BATANERO, Spain. Papers: Teaching hypothesis testing. Can it still be useful), Henrik DAHL, Norway; Some empirical evidences on learning difficulties about testing hypotheses, Angustias VALLECILLOS, Spain; Beyond the significance test controversy: Prime time for Bayes?, Bruno LECOUTRE, France. Reactors: Paul K. ITO, Japan, Michael CAPOBIANCO, USA.

Invited meeting n.59: *Teaching and learning multivariate data analysis*. Organiser/Chair: Helena BACELAR (Portugal). Papers: Introduction à la classification en sciences humaines, Geoges Le Calvé (France); Discussion, debate, and disagreement: Teaching multiple regression to business

students, Peter G. Bryant (USA); Teaching multivariate data analysis in the fields of biology and ecology, Hans-Peter Baeumer (Germany); Some remarks in teaching the correlation coefficient, Kameo Matusita (Japan). Discussants: Gilbert Saporta (France), F. Costa Nicolau (Portugal).

Invited paper meeting n. 60: *Statistical education using flexible learning approaches*. Organiser/Chair Agostino di Ciaccio (Italy). Why do students find statistics so difficult? James B. Ramsey (USA),Teaching statistics with internet: a survey of available resources and the StatNet project, Gilbert Saporta (France), A toolkit for an interactive learning environment, Deborah Nolan and Duncan Temple Lang (USA). Discussants Gianfranco GALMACCI (Italy), Juha Puranen (Finland).

Invited paper meeting n. 61. *Statistical education for life*. Organiser/Chair: Brian PHILLIPS. Papers: Justice by the numbers: Educating judicial decision makers, Mary Gray (USA); Official statistics and the outside world, Vincenzo Lo Moro (Italy); Helping the public understand risk, Amanda Burls (UK). Discussants: John Pidgeon (Australia), Helena BACELAR-Nicolau (Portugal).

Invited paper meeting n. 62: *Issues involved in the assessment and evaluation of student learning*. Organiser: Joan GARFIELD (USA), Chair: Joe Wisenbaker (USA). Papers: How to assess large groups with the minimal amount of resources but preserving quality, Susan STARKINGS (UK). A model of classroom assessment in action: Using assessment to improve student learning and statistical reasoning, Beth CHANCE (USA); Assessment in statistics using the personal computer, Giuseppe Cicchitelli (Italy). Discussants: Gilberte SCHUYTEN (Belgium), Dani BEN-ZVI (Israel).

Invited paper meeting n. 63: *Visualisation as an educational tool* Organiser/Chair Larry Weldon (Canada). Papers: Graphical excellence - The importance of sound principles and practices for effective communication, Thomas E. Bradstreet (USA); Emphasising activities and visualisation in teaching introductory statistics by interactive multimedia, Hans-Joachim Mittag (Germany); Visualisation for teaching all steps of data-based scientific research, Clovis Perez (Brazil). Discussant: Andrej BLEJEC (Slovenia).

Invited paper session n. 42. *Statistical training of people working in and with official statistics*. Session co-organised by IAOS and IASE Organisers/Chairs: Carol Joyce BLUMBERG (USA), René H. M. Smulders (The Netherlands). Papers: The dissemination of statistical literacy among citizens and public administration directors, Luigi Biggeri (Italy); New and emerging demands for statistical training in response to user needs in the 21st century, Ms. Linda Hewitt (West Indies). Discussants: Jayanta K. Ghosh, (India), Mario Palma Rojo (Mexico), Paul Cheung, (Singapore)

---

13. Forthcoming conferences

13.1. International Conference on Mathematics Education Into the 21st Century: Societal Challenges, Issues and Approaches, Cairo, Egypt, November 14-18, 1999

The *Mathematics Education Into The 21st Century Project*, co-ordinated by Dr. Manmohan S. Arora, Associate Director, Mathematics Resources & Technology Centre, Clark Atlanta University, USA, is planning a series of International Conferences to be held throughout the World leading into the next millennium. The first of these will be in Egypt in co-operation with the Third World Forum. It will be chaired by Prof. Ismail-Sabri Abdalla - Former Director of The Institute of National Planning and former Minister of Planning (Egypt). The Local Organising Committee is Chaired by Prof. Fayez M. Mina, Professor of Curriculum and Instruction, Faculty of Education- Ain Shams University, Cairo. The conference will include contributions already made

to the project by leading mathematics educators world-wide. Individual papers are also welcomed from those planning to attend on the themes:

- The impact of new developments in knowledge on mathematics education (eg multiple intelligence, limits to problem solving, mathematics of complexity modelling)
- Societal Conditions (eg mathematics in and for different cultures, linguistical limitations, examples from life and from the environment)
- Information Technology and Society (eg interactive solving of problems, self-learning, modelling and simulating system dynamics)
- Classroom Practice (eg. curriculum development, psychological aspects, the teacher of the 21st Century, creativity).
- Current International Research in the Didactics of Mathematics.
- The Teaching of Statistics and Probability.
- Gender Issues in Mathematics Education

For further information and a copy of the First Announcement please email your contact details to arogerso@mgs.vic.edu.au (or write to Dr. A. Rogerson, 22 Violet Grove, Hawthorn, Vic 3122, Australia).

13.2. ICME 9, Tokyo/Makuhari, Japan, July 31st - 6th August 2000

IASE will have a strong presence at ICME 9. A plenary paper will be given by Mike SHAUGHNESSY, USA, *From research to teaching: What research suggests about teaching data and chance*. More information is available from the conference website: http://www.ma.kagu.sut.ac.jp/~icme-9/index.html

Susan STARKINGS, England, Tae Rim Lee, Korea, Theodore CHADJIPADELIS, Greece, and Professor Kobayashi, Japan, are organising the Topic Study Group TSG4: *The Teaching and Learning of Statistics,* with the theme "Statistics and Statistical Education for the year 2000 plus". People interested in submitting a paper should contact Susan STARKINGS (starkisa@vax.sbu.ac.uk) who have prepared guidelines for preparation of manuscripts. The organisers are looking for papers which feature statistical education issues for students from age 11-18, students in higher education and adults and that will fall in the following categories:

- research that has been carried out on students learning statistics and how this can help the statistical educators of tomorrow;
- new innovations used and/or proposed to be used in the statistics teaching environment;
- practical examples of statistical work carried out in developing countries and the way forward for these countries;
- world related statistical educational and its relationships to the classroom;
- how future statistical education can be enhanced;
- global statistical education for the future.

Final abstracts to be submitted to Susan STARKINS by October 1st, 1999. Final papers to be submitted to Susan Starkins by 15th February, 2000

A Working Group for Action (WGA11) on *The use of technology in mathematics education* will be organised by Rolf BIEHLER, Germany and Barry Kissane, Australia. The WGA will cover a range of levels of education (primary (elementary), secondary (high), post-secondary, teacher education), involve various kinds of technology (calculators, computers, telecommunications, WWW and multimedia) and focus attention on various aspects of mathematics itself (number, space, algebra, statistics, probability, calculus, modelling, etc). Further detailed elaboration of the

scope and direction of the WGA can be obtained from the following website: http://wwwstaff.murdoch.edu.au/~kissane/ICME-9.htm or from one of the organisers:

Rolf BIEHLER, Institut fuer Didaktik der Mathematik (IDM) Universitaet Bielefeld

Postfach 100131, 33501 Bielefeld, Germany Tel: +49-521-106-5058, Fax: +49-521-106-2991 Email: rolf.biehler@uni-bielefeld.de, http://www.uni-bielefeld.de/idm/personen/rbiehler /rbiehler.htm

Barry Kissane, The Australian Institute of Education, Murdoch University, Murdoch WA Australia 6150, Email: kissane@central.murdoch.edu.au, http://wwwstaff.murdoch.edu.au/~kissane

Current List of Chief Organisers of WGA and TG in ICME9

WGA1: Mathematics Education in Pre- and Primary School. Ann Anderson (ann.anderson@ubc.ca) and Linda Sheffield (sheffield@nku.edu)

- *WGA2: Mathematics Education in Junior Secondary School*. Ferdinando Arzarello (arzarello@dm.unito.it) and Alwyn Olivier (aio@akad.sun.ac.za)
- WGA3: Mathematics Education in Senior Secondary School. Abraham Arcavi (ntarcavi@wiccmail.weizmann.ac.il) and Michele Artigue artigue@gauss.math.jussieu.fr)
- WGA4: Mathematics Education in Two-Year Colleges and Other Tertiary Institutions. Marilyn Mays (memays@dcccd.edu).
- WGA5: Mathematics Education in Universities. Lynn Steen (steen@stolaf.edu), and Qixiao Ye (yeqx@sun.ihep.ac.cn).
- WGA6: Adult and Life-long Education in Mathematics. Gail FitzSimons (GFitzsimons@swin.edu.au).
- WGA7: The Professional Pre- and In- service Education of Mathematics Teachers.
- Peter Sullivan (p.sullivan@christ.acu.edu.au) and Ruifen Tang (ftggtf@online.sh.cn).
- WGA8: Research, Practice and Theory of Mathematics Education. Deborah Loewnberg Ball (dball@umich.edu), and Ruhama Even (nteven@wiccmail.weizmann.ac.il)
- WGA9: Communication and Language in Mathematics Education. Bill Barton (b.barton@auckland.ac.nz).
- WGA10: Assessment in Mathematics Education. Ole Bjorkqvist (objorkqv@abo.fi).
- WGA12: The Social and Political Dimensions of Mathematics Education. Christine Keitel-Kreidt (keitel@zedat.fu-berlin.de), Gelsa Knijnik (gelsak@portoweb.com.br).
- WGA13: History and Culture in Mathematics Education. Jan van Maanen (maanen@math.rug.nl), Horng Wann Sheng (horng@math.ntnu.edu.tw).
- TSG5: Teaching and Learning Aids and Materials (Hands-On) in Mathematics Education. Salvador Guerrero (sguerre@cica.es), Jin Akiyama (fwjb5117@mb.infoweb.ne.jp).
- TSG6: Distance Learning in Mathematics Education. David Crowe (UK) (W.D.Crowe@open.ac.uk).
- TSG7: The Use of Multimedia in Mathematics Education. Guenter Krauthausen (krauthausen@rrz.uni-hamburg.de), Katsuhiko Shimizu (shimizu@nier.go.jp).
- TSG8: Vocational Mathematics Education, Clive Kanes (C.Kanes@edn.gu.edu.au).
- TSG9: Mathematical Modeling and Links between Mathematics and Other Subjects
- Werner Blum (Germany) (blum@did.mathematik.uni-kassel.de), Peter Galbraith (Australia) (p.galbraith@mailbox.uq.edu.au).
- TSG10: The Trends in Mathematics and the Mathematical Sciences; Their Reflections on Mathematics Education. Nestor Aguilera (aguilera@fermat.arcride.edu.ar).
- TSG11: Problem Solving in Mathematics Education Erkki Pehkonen

(epehkonen@bulsa.helsinki.fi), Young Han Choe (Korea) (yhchoe@cais.kaist.ac.kr).
- TSG12: Proof and Proving in Mathematics Education. Paolo Boero (boero@cartesio.dima.unige.it).
- TSG13: Mathematical Learning and Cognitive Processes. Fou Lai Lin (linfl@math.ntnu.edu.tw).
- TSG14: Constructivism in Mathematics Education. Koeno Gravemeijer (koeno@fi.ruu.nl). Jeong-Ho Woo (wjh@plaza.snu.ac.kr).
- TSG15: Mathematics Education for Students with Special Needs. Sughakar Agarkar (S.Agarkar@open.ac.uk)
- TSG16: Creativity in Mathematics Education and the Education of Gifted Students
- Hartwig Meissner (meissne@uni-muenster.de) M. Katheleen Heid (ik8@psu.edu)
- TSG17: Mathematics Education and Equity. Robyn Zevenbergen (r.zevenbergen@mailbox.gu.edu.au).
- TSG18: Mathematics Competitions in Mathematics Education. Titu Andreescu (Titu@amc.unl.edu), Claude Deschamps (cl.deschamps@wanadoo.fr).
- TSG19: Entrance Examinations and Public Examinations in Mathematics Education.
- Shigeru Iitaka (851051@gakushuin.ac.jp)
- TSG20: Art and Mathematics Education. Vera Spinadel (Argentine) (postmast@caos.uba.ar).
- TSG21: Ethnomathematics. Ubiratan D'Ambrosio (ubi@pucsp.br).
- TSG22: Topics in Mathematics Education in Asian Countries. Bienvenido F. Nebres (bnebres@pusit.admu.edu.ph), Zhang Dianzhou (China) (dzzhang@fudan.ac.cn).
- TSG23: TIMSS and Comparative Studies in Mathematics Education. Liv Sissel Gronmo (l.s.gronmo@ils.uio.no), Berinderjeet Kaur (bkaur@nie.edu.sg).

13.3. ICOTS-6 Durban (South Africa), 2002

Plans to held ICOTS-6 in the Summer of 2002 are already under way. The venue is Durban, in South Africa, during mid July. The IASE will make a concerted effort to attract participation from African developing nations, in part offering funds to delegates as was the case at ICOTS-5.

Local Organising Committee Executive

- Linda Haines haines@stat.unp.ac.za (President SASA)
- Delia North, delian@icon.co.za (Chair of the LOC)

International Programme Committee, IPC

IPC Executive

- **Maria-Gabriella Ottaviani (Italy) Chair** ottavian@pow2.sta.uniroma1.it
- **Brian PHILLIPS (Australia) International Organiser** bphillips@swin.edu.au
- **Dani BEN-ZVI (Israel) IPC Secretary** ntdben@wiccmail.weizmann.ac.il
- **Delia North (South Africa) Chair of the Local Organising Committee** delian@icon.co.zal

Topic Convenors

1. SCHOOL LEVEL Lionel PEREIRA-MENDOZA (Singapore) lpereira@nie.edu.sg
2. POST SECONDARY Gilberte SCHUYTEN (Belgium) Gilberte.Schuyten@rug.ac.be
3. WORKPLACE Carol Joyce BLUMBERG (USA) wncarolj@vax2.winona.msus.edu and René H. M. Smulders (The Netherlands) RSLS@cbs.nl
4. WIDER SOCIETY Helen MacGillivray (Australia) h.macgillivray@fsc.qut.edu.au
5. INTERNATIONAL PERSPECTIVE Vitalis Muba (Tanzania) eastc@ud.co.tz
6. RESEARCH Carmen BATANERO (Spain) batanero@goliat.ugr.es and Joan GARFIELD (USA) jbg@maroon.tc.umn.edu
7. TECHNOLOGY Lawrence Weldon (Canada) weldon@sfu.ca
8. OTHER DETERMINANTS Philip J. Boland (Ireland) Philip.J.Boland@ucd.ie
9. LOCAL TEACHERS Tyna LAMPRECHT (South Africa) ajl4@icon.co.za

IASE encourages members to submit suggestions for session topics, for organisational arrangements, or other areas. ICOTS is IASE major conference; we want it to respond to members' wishes. Any suggestions or other communication from interested members relevant to the activity of the IPC will be welcomed by M.Gabriella OTTAVIANI (ottavian@pow2.sta.uniroma1.it) and Brian PHILLIPS (bphillips@swin.edu.au). A temporary web site has been set up at http://www.swin.edu.au/maths/icots6/welcome.html