



Statistics Education Research Journal

Volume 4 Number 1 May 2005

Editors

*Flavia Jolliffe
Iddo Gal*

Assistant Editor

Christine Reading

Associate Editors

*Andrej Blejec
Joan B. Garfield
John Harraway
M. Gabriella Ottaviani
Lionel Pereira-Mendoza
Maxine Pfannkuch
Mokaeane Polaki
Dave Pratt
Ernesto Sanchez
Richard L. Scheaffer
Gilberte Schuyten
Jane Watson*

International Association for Statistical Education
<http://www.stat.auckland.ac.nz/~iase>

International Statistical Institute
<http://www.cbs.nl/isi>

Statistics Education Research Journal

SERJ is a peer-reviewed electronic journal of the International Association for Statistical Education (IASE) and the International Statistical Institute (ISI). SERJ is published twice a year and is free.

SERJ aims to advance research-based knowledge that can help to improve the teaching, learning, and understanding of statistics or probability at all educational levels and in both formal (classroom-based) and informal (out-of-classroom) contexts. Such research may examine, for example, cognitive, motivational, attitudinal, curricular, teaching-related, technology-related, organizational, or societal factors and processes that are related to the development and understanding of stochastic knowledge. In addition, research may focus on how people use or apply statistical and probabilistic information and ideas, broadly viewed.

The Journal encourages the submission of quality papers related to the above goals, such as reports of original research (both quantitative and qualitative), integrative and critical reviews of research literature, analyses of research-based theoretical and methodological models, and other types of papers described in full in the Guidelines for Authors. All papers are reviewed internally by an Associate Editor or Editor, and are blind-reviewed by at least two external referees. Contributions in English are recommended. Contributions in French and Spanish will also be considered. A submitted paper must not have been published before or be under consideration for publication elsewhere.

Further information and guidelines for authors are available at: <http://www.stat.auckland.ac.nz/serj>

Submissions

Manuscripts must be submitted by email, as an attached Word document. Manuscripts submitted before 1 November 2005 should be sent to co-editor Flavia Jolliffe <F.Jolliffe@kent.ac.uk>. Manuscripts submitted after 1 November 2005 should be sent to co-editor Iddo Gal <iddo@research.haifa.ac.il>. These files should be produced using the Template available online. Full details regarding submission are given in the Guidelines for Authors on the Journal's Web page: <http://www.stat.auckland.ac.nz/serj>

© International Association for Statistical Education (IASE/ISI), May, 2005

Publication: IASE/ISI, Voorgurg, The Netherlands

Technical Production: University of New England, Armidale, NSW, Australia

ISSN: 1570-1824

International Association for Statistical Education

President: Gilberte Schuyten (Belgium)

President-Elect: Allan Rosman (United States of America)

Past- President: Chris Wild (New Zealand)

Vice-Presidents: Andrej Blejec (Slovenia), John Harraway (New Zealand), Christine Reading (Australia), Michiko Watanabe (Japan), Larry Weldon (Canada)

SERJ EDITORIAL BOARD

Editors

Flavia R. Jolliffe, Institute of Mathematics, Statistics and Actuarial Science, University of Kent, Canterbury, Kent, CT2 7NF, United Kingdom. Email: F.Jolliffe@kent.ac.uk

Iddo Gal, Department of Human Services, University of Haifa, Eshkol Tower, Room 718, Haifa 31905, Israel. Email: iddo@research.haifa.ac.il

Assistant Editor

Christine Reading, SiMERR National Centre, Faculty of Education, Health and Professional Studies, University of New England, Armidale, NSW 2351, Australia. Email: creading@une.edu.au

Associate Editors

Andrej Blejec, National Institute of Biology, Vecna pot 111 POB 141, SI-1000 Ljubljana, Slovenia. Email: andrej.blejec@uni.si

Joan B. Garfield, Educational Psychology, 315 Burton Hall, 178 Pillsbury Drive, S.E., Minneapolis, MN 55455, USA. Email: jbg@umn.edu

John Harraway, Dept of Mathematics and Statistics, University of Otago, P.O.Box 56, Dunedin, New Zealand. Email: jharraway@maths.otago.ac.nz

M. Gabriella Ottaviani, Dipartimento di Statistica Probabilità e Statistiche Applicate, Università degli Studi di Roma "La Sapienza", P.le Aldo Moro, 5, 00185, Rome, Italy. Email: Mariagabriella.ottaviani@uniroma1.it

Lionel Pereira-Mendoza, National Institute of Education, Nanyang Technological University, 1 Nanyang Walk, Singapore 637616. Email: lpereira@nie.edu.sg

Maxine Pfannkuch, Mathematics Education Unit, Department of Mathematics, The University of Auckland, Private Bag 92019, Auckland, New Zealand. Email: m.pfannkuch@auckland.ac.nz

Mokaeane Polaki, School of Education, National University of Lesotho, P.O. Box Roma 180, Lesotho. Email: mv.polaki@nul.ls

Dave Pratt, Centre for New Technologies Research in Education, Institute of Education, University of Warwick, Coventry CV4 7AL, United Kingdom. Email: dave.pratt@warwick.ac.uk

Ernesto Sanchez, Joaquín Romo # 68 – 9, Col. Miguel Hidalgo; Del. Tlalpan, 14260 México D. F. Email: esanchez@cinvestav.mx

Richard L. Scheaffer, Department of Statistics, University of Florida, 907 NW 21 Terrace, Gainesville, FL 32603, USA. Email: scheaffe@stat.ufl.edu

Gilberte Schuyten, Faculty of Psychology and Educational Sciences, Ghent University, H. Dunantlaan 1, B-9000 Gent, Belgium. Email: Gilberte.Schuyten@UGent.be

Jane Watson, University of Tasmania, Private Bag 66, Hobart, Tasmania 7001, Australia. Email: Jane.Watson@utas.edu.au

TABLE OF CONTENTS

Editorial	2
New Associate Editors	4
Call for Nominations for New Co-Editor	5
Call for Papers: Reasoning about Distributions	6
Linda Collins and Kathleen Mittag <i>Effect of Calculator Technology on Student Achievement in an Introductory Statistics Course</i>	7
Elena C. Papanastasiou <i>Factor Structure of the “Attitudes Toward Research” Scale</i>	16
Special Section: Reasoning about Variation Guest Editors: Joan Garfield and Dani Ben-Zvi	
Katie Makar and Jere Confrey <i>“Variation Talks”: Articulating Meaning in Statistics</i>	27
Bob delMas and Yan Liu <i>Exploring Students’ Conceptions of the Standard Deviation</i>	55
Maxine Pfannkuch (Invited) <i>Thinking Tools and Variation</i>	83
Joan Garfield and Dani Ben-Zvi (Invited) <i>A Framework for Teaching and Assessing Reasoning about Variability</i>	92
Past IASE Conferences	100
Other Past Conferences	104
Forthcoming IASE Conferences	105
Other Forthcoming Conferences	108

EDITORIAL

SERJ is in its fourth year of operation and it is clear that it is now well established as the research journal of the International Association for Statistical Education (IASE). The flow of new manuscripts, as well as their breadth, are increasing, and represent the growing interest in research and in new knowledge that can inform practice in statistics education. That said, many areas of importance for statistics education are underrepresented in current research, such as: learning about associations and correlations, learning advanced topics such as regression or inference testing, the link between knowledge of probability and learning of statistical inference, students' ability to apply and transfer knowledge to out-of-school situations which require activation of statistical understanding, or factors that affect and programs that can improve adults' understanding of real-world statistical messages and arguments.

The selected examples given above are far from being exhaustive; they are provided merely to illustrate the range of research areas that have a potential to contribute to improvement of statistics learning, teaching, and application by people in different educational, cultural and functional contexts. We encourage researchers and educators from diverse disciplines to collaborate, and to consider expanding and extending research plans, in order to address the research and practice needs of the international statistics education community.

This issue contains six papers, four of which appear in a special section on research on variation, which extends the special issue we published in November 2004 on that topic. We thank Joan Garfield and Dani Ben Zvi, who were the Guest Editors both for the former special issue as well as for the special section in the current issue, for their work and initiative regarding this important area.

The four papers on variation include two refereed research papers (Makar & Confrey; delMas & Liu) and two invited discussion papers (Garfield & Ben-Zvi; Pfannkuch). Katie Makar and Jere Confrey examine how prospective secondary mathematics and science teachers understand and articulate notions of variation as they compare two distributions. Bob delMas and Yan Liu examine students' understanding of the standard deviation, and the impact of using a customized computer applet, on their reasoning about the link between spread and center. Maxine Pfannkuch discusses broad implications of the empirical papers on reasoning about variation published in the November 2004 special issue, with an emphasis on the role of tools in students' learning and in future research, and the link between learning about variation and broader aspects of the statistical enquiry cycle. Joan Garfield and Dani Ben-Zvi further extend their reflection based on the empirical papers on reasoning about variation, by pointing to a model that can inform instruction, assessment, and future research. This issue also includes two regular research papers. Linda Brant Collins and Kathleen Mittag deal with the use of calculators in teaching statistics and their paper fills an important gap in the literature. Elena Papanastasiou describes a scale developed to measure "attitudes towards research" of college students, thus adding to the literature that so far has focused more on attitudes and beliefs regarding statistics.

We now turn to a brief report of changes and future plans at SERJ.

First, we plan a special issue on research on "learning and teaching of reasoning about distributions" for November 2006. A preliminary announcement was circulated a few months ago, and a more detailed Call for Papers appears later in this issue. The deadline for submissions is 1 November 2005. Interested authors are asked to submit a letter of intent and to follow the guidelines in the Call for Papers.

Second, there have been some recent changes to our editorial board. Three associate editors have departed, Carmen Batanero, Annie Morin, and Chris Wild. We thank all three for the many

contributions they have made to the development of SERJ while serving on the board. Carmen was a founding Editor and was instrumental in the transition from the former *Statistical Education Research Newsletter*. Chris was also involved with SERJ from the start and Annie joined soon after. Chris, while president of IASE, developed the Association's web pages and SERJ's web page is naturally part of that site. We welcome two new associate editors, Gilberte Schuyten from Belgium, and Ernesto Sanchez from Mexico. Biographical notes for both are given on the next page.

Third, Flavia Jolliffe's four-year term as co-editor ends on 31 December 2005. The search for a new co-editor is progressing, following a procedure recently formalised by the IASE Executive. A 3-person search committee is being formed, consisting of a member of the IASE Executive (chair) appointed by the IASE president, the continuing co-editor, and a member-at-large of IASE who is neither on the IASE Executive nor on the SERJ editorial board. A Call for Nominations is published later in this issue as well as on the IASE website under 'Publications'.

Fourth, we continue updating the guidelines for authors and other SERJ documentation. We expect the revised guidelines to be available in July 2005 and encourage prospective authors to examine these materials and follow them in future submissions. We take this opportunity to express our gratitude to Chris Reading, SERJ's Assistant Editor, for the many hours she puts in, and the care she takes, in producing SERJ to a high professional standard.

Finally, now that plans are well underway for ICOTS7 in 2006 and for many other conferences where research papers in statistics education are presented, we would like to remind prospective authors to be attentive to "prior publication" or "duplicate publication" policies which different journals apply. Like many journals, SERJ's policy is that papers already published, i.e., available for wide public consumption via the Internet or other electronic or printed means, cannot be accepted for consideration by SERJ. In the case of submissions based on papers previously published in conference proceedings, whether in print or electronically, we expect that submitted papers will be *substantially different or expanded*. This usually does not present a problem as many conferences typically pose a limit on word/page count, so what is published is limited in scope from the outset. The upshot is that authors have to strategize in advance what selected portions they submit for publication in conference proceedings and what additional materials, results, analyses, and discussions will be added and be exclusive to manuscripts submitted for journal consideration and review. As will be explained in our revised guidelines, authors will be expected to declare upon submission if a paper or a portion of it was previously published in any form. Authors are encouraged to consult the editors in advance if doubts exist as to what constitutes prior publication, in order to maximize the match of author intentions and journal expectations, and make sure authors find a suitable outlet for their research work.

In closing, we reiterate our conviction that the Journal is supposed to serve a diverse and expanding community of practitioners and researchers interested in statistics education and learning in diverse fields and contexts. We thus encourage all readers of SERJ to send us comments and suggestions regarding the journal, its scope, papers it publishes, and ideas for future plans.

IDDO GAL AND FLAVIA JOLLIFFE

NEW ASSOCIATE EDITORS

SERJ welcomes the following new Associate Editors, who have joined the Editorial Board for a 3-year appointment 2005-2007.

Ernesto Sanchez has a Ph. D. in Mathematics Education with a further background in mathematics. He is a Researcher at the Center for Research and Advanced Studies of 'Instituto Politécnico Nacional' in Mexico. His research interests have focused on topics of teaching and learning of probability such as stochastic independence, conditional probability, and relationships between probabilistic thinking and technology. He has published numerous research articles in statistics education in the Spanish language. Recently he was a coauthor with Carmen Batanero of a chapter 'What is the nature of high school student's conceptions and misconceptions about probability?' in the book by Graham Jones (2005) on research and teaching of probability in schools.

Gilberte Schuyten is Professor and Head of the Department of Data Analysis at the Faculty of Psychology and Educational Sciences at Ghent University, Belgium. She teaches data analysis and empirical research methods at the Faculty. Her Ph.D. is in Mathematics from Ghent University (1971). As a young researcher she started 'new math' experiments in the late sixties, and later her research interests centered on technology and the school curriculum. She introduced Logo in Belgium, organized training courses for Flemish teachers, and directed projects of the Flemish government aimed at using ICT in statistics courses at universities. At the European level she has organized international meetings and conferences about information technologies at school. Her primary interest is the influence of cognitive and affective characteristics and the use of electronic technologies on statistics learning of students in the social sciences.

CALL FOR NOMINATIONS FOR NEW CO-EDITOR: STATISTICS EDUCATION RESEARCH JOURNAL

The International Association for Statistical Education (IASE) is starting a search for the next co-editor of *Statistics Education Research Journal* (SERJ), its peer-reviewed electronic journal. The new editor will serve a four-year term starting Jan 1, 2006, replacing Flavia Jolliffe (U. of Kent, UK), who will end her four-year tenure in Dec 2005. The new editor will join Iddo Gal (U. of Haifa, Israel), the continuing co-editor until Dec 2007.

SERJ was established in 2002 by IASE to advance research-based knowledge that can help to improve the teaching, learning, and understanding of statistics or probability at all educational levels and in both formal and informal contexts. The breadth and scope of manuscripts submitted to SERJ are increasing and represent the growing interest in research and in new knowledge that can inform practice in statistics education. The SERJ organization includes two co-editors who serve for 4 years (one is replaced every two years), an Assistant Editor in charge of copy-editing and production, and an Editorial Board presently comprised of 12 Associate Editors from 10 countries. SERJ issues and materials are published on the IASE website, presently hosted by the University of Auckland (NZ). The journal maintains autonomy regarding content and process, although some activities are coordinated with IASE and its parent organization and co-publisher, the International Statistical Institute (ISI). All journal activities are conducted electronically. Board members meet during key international conferences such as ICOTS or ISI. SERJ is a virtual organization and it operates on the basis of voluntary work by all board members and editors.

The co-editors are responsible for overall management of all journal operations, determine the composition of the Editorial Board and the reviewer pool, initiate and conduct communication with prospective authors, reviewers, associate editors, and external stakeholders, and manage peer-review and editorial processes. The co-editors are expected to establish editorial policies, set scholarly and quality expectations, and uphold acceptance criteria regarding manuscripts. The co-editors should have a forward-looking vision and initiate new features and structures, if needed in consultation with Board members and others, so as to enable SERJ to respond to the evolving knowledge needs in the dynamic area of statistics education. Overall, the co-editors should lead the journal to make an important contribution to research and practice in statistics education.

The qualified individual will have a research and practice background of relevance to statistics education, possess the skill to work with prospective contributors in a supportive yet critical spirit, and be able to maintain and strengthen international professional networks of authors and reviewers and enhance the Journal's reputation and impact.

The search process and how to apply

IASE encourages both nominations of suitable candidates and self-nominations from interested individuals. All nominations and self-nominations will be considered by the Search Committee, which can also propose additional nominees. Candidates or self-nominees will be asked to prepare a brief statement describing their vision for continuing the growth and development of the Journal, along with a statement of their qualifications for the position, and an academic vita or professional resume. Candidates might also be asked to respond to additional questions by the search committee.

For more information about the search process, or to submit a nomination, please contact the Chair of the Search Committee, Chris Wild, (U. of Auckland. NZ): <c.wild@auckland.ac.nz>. Questions about the practicalities of the editorship can be sent to either the continuing co-editor, Iddo Gal <iddo@research.haifa.ac.il> or to the departing co-editor, Flavia Jolliffe: <F.Jolliffe@kent.ac.uk>. Nominations should be submitted as soon as possible, preferably not later than July 15, 2005. The editorial change is expected to occur January 1, 2006.

CALL FOR PAPERS: REASONING ABOUT DISTRIBUTIONS

The *Statistics Education Research Journal* (SERJ), a journal of the International Association for Statistical Education (IASE), is planning a special issue for November 2006, focused on research on reasoning about distributions. Submission Deadline: November 1, 2005.

The aim of the special issue is to advance the current state of research-based knowledge about the learning and teaching of reasoning about distributions, and to contribute to future research and to research-based practice in this area. Little research, whether qualitative or quantitative, has been published to date in this area, despite “distribution” being a foundational topic in statistics and one of the underpinnings of statistical literacy. Many research challenges exist, such as regarding knowledge of students and educators in diverse contexts of learning distribution-related ideas (e.g., K-12, tertiary, workplace), effective curricular materials and tools, or methods for documenting knowledge or measuring performance on tasks that require understanding of distributions.

Examples for relevant topics for research-oriented papers include (but are not limited to):

- How students or adults understand distributions, or make use of information about distributions, whether as a stand alone topic or in relation to reasoning about other statistical topics or tasks (e.g., involving variation, statistical inference, probability),
- How technological tools are utilized by learners to generate representations or improve thinking about distributions,
- What developmental trajectories exist, e.g., in acquisition of informal and formal knowledge about distributions, in learning to represent distributions, in proficiency in interpreting information or displays about distributions,
- How students interpret information regarding distributions when generated by technology or other means, and how these interpretations can be improved,
- What misconceptions and difficulties can be seen when students or adults think about or work with information about distributions, and what may be their origins,
- How does learners’ knowledge of distributions, or difficulties they encounter in this regard, contribute to or impede their behavior and thinking when coping with tasks involving other topics in statistics and probability,
- Knowledge and perspectives of educators involved in teaching about distributions,
- The relative efficacy of teaching approaches or curricular materials that can promote the understanding of distributions or their use in various tasks,
- Innovative assessment approaches and research methodologies in this area.

Manuscripts will be limited to a maximum of 8500 words of body text (not counting abstract, tables and graphs, references, appendices). Shorter, concise papers are preferred. Manuscripts will be reviewed following SERJ’s regular double-blind refereeing process. Guest Editors of this special issue will be Maxine Pfannkuch (University of Auckland, New Zealand) and Chris Reading (University of New England, Australia).

Interested authors are asked to send a letter of intent with details of the planned paper, or any queries, to Iddo Gal, SERJ co-editor, at: <iddo@research.haifa.ac.il>. Manuscripts must be submitted by November 1, 2005 to the same address, using the SERJ Author Guidelines and Template found on: <www.stat.auckland.ac.nz/serj>. (Please be advised that the Author Guidelines and Template will be updated in July 2005.)

EFFECT OF CALCULATOR TECHNOLOGY ON STUDENT ACHIEVEMENT IN AN INTRODUCTORY STATISTICS COURSE

LINDA BRANT COLLINS
University of Chicago
collins@galton.uchicago.edu

KATHLEEN CAGE MITTAG
University of Texas at San Antonio
kmittag@utsa.edu

SUMMARY

We report on a study of the relationship between calculator technology and student learning in two introductory statistics class sections taught by the same instructor at the University of Texas at San Antonio. At the introduction of hypothesis testing and confidence intervals, one class section (A) was given graphing calculators capable of inferential statistics to use for a few weeks. At the same time, the other class section (B) was given non-inferential graphing calculators. Data were collected on all test grades and daily quiz grades for both class sections. The students were allowed to use the inferential calculators on only the examination covering hypothesis tests and confidence intervals and on the final examination. Both sections received the same tests. We found that although use of the calculator with inferential capabilities is associated with improved scores on the inferential examination, the improvement is not significant once we adjust for performance on previous tests. Still, we note that on final examination questions specifically utilizing the calculator inference functions, the two classes perform similarly. In fact, both classes had trouble with “calculations” while at the same time answering “concept” questions fairly well. The inferential calculator did not appear to give students any clear advantage or disadvantage in their performance on examinations.

Keywords: Statistics education research; Introductory statistics; Graphing calculator; Inferential calculator; Student achievement

1. INTRODUCTION

Since calculators with inferential statistics capabilities came on the market in January, 1996, it has become evident that statistics educators need to analyze the effectiveness of the new hand-held technology. It is interesting to note that many statistics instructors at our university were not aware of these calculators and this may also be true at many other universities.

We studied the effect of calculator technology on student achievement in two introductory statistics class sections taught by one of the authors in autumn, 1998, at a large public urban university in the United States. At the introduction of the topics of hypothesis testing and confidence intervals, one class section (Class A) was given inferential calculators to use for a few weeks. At the same time, the other class section (Class B) was given older calculators without inferential capabilities. Other than this difference in calculators, the two groups were treated as similarly as possible.