

STATISTICS EDUCATION RESEARCH JOURNAL

Volume 18
Number 1
May 2019



EDITORS

Manfred Borovcnik
Jennifer J. Kaplan

ASSISTANT EDITOR

Beth Chance

ASSOCIATE EDITORS

Egan Chernoff Stefania Mignani
Sue Finch Michele Millar
Noleine Fitzallen Jennifer Noll
Randall Groth M. Gabriella Ottaviani
Leigh Harell-Williams Susan Peters Susanne
Aisling Leavy Schnell
Alejandra Sorto

STATISTICS EDUCATION RESEARCH JOURNAL

The *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 open access.

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://iase-web.org/Publications.php?p=SERJ>

Submissions

Manuscripts must be submitted by email, as an attached Word document, to co-editor Jennifer Kaplan <jkaplan@uga.edu>. Submitted manuscripts should be produced using the Template file and in accordance with details in the Guidelines for Authors on the Journal's Web page:
<http://iase-web.org/Publications.php?p=SERJ>

© International Association for Statistical Education (IASE/ISI), May 2019

Publication: IASE/ISI, The Hague, The Netherlands

Technical Production: California Polytechnic State University, San Luis Obispo, California, United States of America

ISSN: 1570-1824

International Association for Statistical Education (IASE) – an association of the International Statistical Institute (ISI)

President: Gail Burrill (USA)

President-Elect: Joachim Engel (Germany)

Past-President: Andrej Blejec (Slovenia)

Vice-Presidents: Ayse Bilgin (Australia), Stephanie Budgett (New Zealand), Pedro Campos (Portugal), Thi Thanh Loan le (Vietnam), Teresita Terán (Argentina)

SERJ EDITORIAL BOARD

Editors

Manfred Borovcnik, Department of Statistics Alpen-Adria, Universität Klagenfurt, Austria. Email: manfred.borovcnik@aau.at

Jennifer J. Kaplan, Department of Statistics, University of Georgia, 401 Brooks Hall, 310 Herty Drive, Athens, Georgia 30601, USA. Email: jkaplan@uga.edu

Assistant Editor

Beth Chance, Department of Statistics, California Polytechnic State University, San Luis Obispo, California, 93407, USA. Email: bchance@calpoly.edu

Associate Editors

Egan Chernoff, College of Education, University of Saskatchewan, Saskatoon SK S7N0X1, Canada. Email: egan.chernoff@usask.ca

Sue Finch, Statistical Consulting Centre, The University of Melbourne, Australia. Email: sfinch@unimelb.edu.au

Noleine Fitzallen, School of Education, College of Arts, Law, and Education, University of Tasmania, Australia. Email: noleine.fitzallen@utas.edu.au

Randall E. Groth, Department of Education Specialties, Salisbury University, Salisbury, MD 21801, USA. Email: regroth@salisbury.edu

Leigh Harrell-Williams, Department of Counseling, Educational Psychology & Research, University of Memphis, Memphis, TN 38152, USA. Email: lmwllm14@memphis.edu

Aisling Leavy, Department of Language, Literacy and Mathematics Education, Mary Immaculate College, University of Limerick, Limerick, Ireland. Email: aisling.leavy@mic.ul.ie

Stefania Mignani, Dipartimento di Scienze Statistiche, Università di Bologna, Italy. Email: stefania.mignani@unibo.it

Michele Millar, Department of Mathematics and Computer Science, Mount Saint Vincent University, Halifax, Nova Scotia, Canada. Email: michele.millar@msvu.ca

Jennifer Noll, Fariborz Maseeh Department of Mathematics and Statistics, Portland State University, Portland, Oregon, USA. Email: noll@pdx.edu

Maria Gabriella Ottaviani, Retired, Università degli Studi di Roma "La Sapienza", Rome, Italy. Email: ottavianimariagabriella@gmail.com

Susan Peters, Department of Middle and Secondary Education, College of Education and Human Development, University of Louisville, Louisville, KY, USA. Email: s.peters@louisville.edu

Susanne Schnell, University of Paderborn, Institute of Mathematics, Paderborn, susanne.schnell@math.upb.de

M. Alejandra Sorto, Department of Mathematics, Texas State University, San Marcos, TX 78666, USA. Email: sorto@txstate.edu

Douglas Whitaker, Department of Mathematics and Computer Science, Mount Saint Vincent University, Halifax, Nova Scotia, Canada. Email: douglas.whitaker@msvu.ca

TABLE OF CONTENTS

Editorial	4
Call for Papers: Statistics Education Research from a Latin American Perspective	6
Maria Guadalupe Tobías-Lara and Ana Luisa Gómez-Blancarte <i>Assessment of Informal and Formal Inferential Reasoning: A Critical Research Review</i>	8
Kelly Findley and Alexander Lyford <i>Investigating Students' Reasoning about Sampling Distributions Through a Resource Perspective</i>	26
Noelle M. Crooks, Anna N. Bartel, and Martha W. Alibali <i>Conceptual Knowledge of Confidence Intervals in Psychology Undergraduate and Graduate Students</i>	46
Jeremy F. Strayer, Natasha E. Gerstenschlager, Lisa B. Green, Nancy McCormick, Scott McDaniel, and Ginger Holmes Rowell <i>Toward a Full(er) Implementation of Active Learning</i>	63
Inger Persson, Katrin Kraus, Lisbeth Hansson, and Fan Yang Wallentin <i>Confirming the Structure of the Survey of Attitudes Toward Statistics (SATS-36) by Swedish Students</i>	83
Daniel LaLande, Michael Cantinotti, Alexandre Williot, Joel Gagnon, and Denis Cousineau <i>Three Pathways from Achievement Goals to Academic Performance in an Undergraduate Statistics Course</i>	94
Ugorji I. Ogbonnaya and Francis K. Awuah <i>Quintile Ranking of Schools in South Africa and Learners' Achievement in Probability</i>	106
Conferences	120

EDITORIAL

Welcome to the first issue of *SERJ* for 2019. As the *SERJ* Editor of Regular Papers for 16 months, I have developed an even greater appreciation for the work done by my predecessor, Maxine Pfannkuch, in streamlining the *SERJ* review process and providing a system under which papers are moving smoothly through the review process. While she left large shoes to fill, Maxine prepared the volunteer editorial staff well, and was able to shepherd all of her papers through final review and to publication by the end of 2018. We thank her once again for her service to *SERJ*. In addition, I would like to thank the Associate Editors, Manfred Borovcnik, Editor for the Special Issues, and Beth Chance, the Assistant Editor. Without their dedicated service to the mission of *SERJ*, the publication of this issue would not have been possible.

All of the papers in this issue are new submissions starting from the beginning of my term as the *SERJ* Editor of Regular Papers. As a group, the papers reflect the diversity of the readership of our journal not only in the content covered, but also in the methodologies used and the countries of origin. The first paper, authored by researchers from Mexico, uses literature review to map the domain of formal and informal inferential reasoning. This paper is followed by two papers from US-based authors who use qualitative methods to describe student understanding of sampling distributions and confidence intervals, respectively. A final qualitative paper addresses the development and use of active learning material in undergraduate statistics classes in the US. The final three papers use quantitative methods: the first to confirm the factor structure of the Swedish version of the SATS, the second to test pathways Canadian students take to reach their goals in statistics courses, and the third to identify socioeconomic differences in the learning of probability in South Africa.

Maria Guadalupe Tobías-Lara and Ana Luisa Gómez-Blancarte present a literature review of research on how informal and formal inferential reasoning have been conceptualized and assessed. They found that previously published descriptions of IIR and FIR typically list the facts from the analysis of data students use in the process of inferential reasoning. The authors suggest that conceptions of IIR and FIR may need to be revised to create more integrated descriptions that include argumentation. In brief, they propose that assessment of students' inferential reasoning might be strengthened if we consider the reasons students provide to support inferential decisions in addition to the facts on which the decisions are based.

Kelly Findley and Alex Lyford move the field of statistics education away from a deficit model of student understanding in which researchers document student misconceptions or shortcomings to a more constructivist model in which they consider resources students use to construct statistical knowledge, some more productive than others. In the study described, Findley and Lyford used interviews with undergraduate students to identify the resources students use to construct knowledge about sampling distributions. Their results illustrate not only how students can construct knowledge, but also the importance of framing students as capable reasoning agents in the learning environment.

Noelle Crooks, Anna Bartel, and Martha Alibali assessed conceptual knowledge of confidence intervals in undergraduate and graduate psychology students. While they found that both groups were prone to misconceptions, they also found that connecting confidence intervals to estimation and sample mean concepts was associated with deeper conceptual knowledge of confidence intervals. The same was not true of connections made to null hypothesis significance testing. In an age in which both the American Statistical Association (ASA) and the American Psychological Association (APA) have issued statements about decreasing emphasis on reporting of p -values and increasing emphasis on reporting of effect sizes and/or confidence intervals, this research is rather timely. The results of this study provide direction for researchers studying the potential learning and curricular effects of changing the focus of statistics instruction from p -values to confidence intervals.

Jeremy Strayer and his colleagues used design experiment methodology to create active-learning materials for introductory statistics class. In their paper, they not only describe the process through which they created the materials, they also frame the design within the approaches to active-learning found in the statistics education literature. In addition, the authors used an embedded case study methodology to uncover factors that inform more effective and/or complete implementation of active-

learning strategies in the classroom. As the evidence in support of the use of active-learning strategies at the tertiary level mounts, this work provides a model for successful uptake of these strategies by statistics instructors.

Inger Persson and colleagues confirmed the six-factor structure of the pretest version of the Survey of Attitudes Towards Statistics (SATS-36) using a sample of Swedish undergraduate students. While the results suggest that the items and six factors are conceptually relevant, they also suggest a few modifications to the original model structure of the SATS-36. The authors remind us of the importance of positive attitudes on learning as well as keeping our research instrumentation up to date in the changing landscape of statistics and data science.

Daniel Lalonde and colleagues used structural equation modeling (SEM) to test three pathways from achievement goals to academic performance for undergraduate students in psychology taking an introductory course on statistics. The results reveal three distinct paths from achievement goals to academic performance: the more participants adopted mastery goals in the context of their statistics course, the less they experienced anxiety and the better they performed in the course at the end of the semester. These findings may help instructors encourage students to set goals in a way that will reduce student anxiety and improve student learning.

Ugorji Ogbonnaya and Francis Awuah investigated the level of learning of probability exhibited by students in schools comprising the first four socioeconomic quintiles in South Africa. Using an ex-post-facto research design, with Bloom's taxonomy as the conceptual framework, the authors found that learners in the second highest socioeconomic quintile had higher probability achievement scores than learners from the three lower quintiles, but that students in the lowest quintile scored significantly higher than students from the second and third lowest quintiles. These results may help the government in South Africa distribute funding in a way that might better address the learning gap across the socioeconomic levels of the communities in which schools are located.

JENNIFER J. KAPLAN